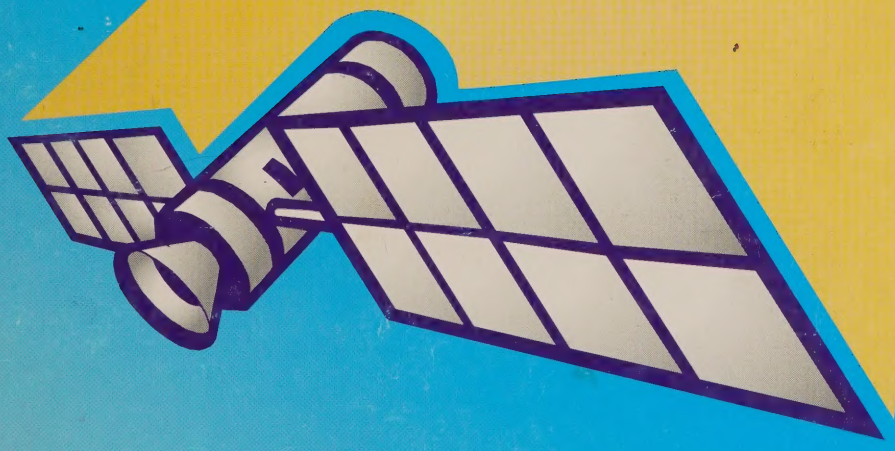
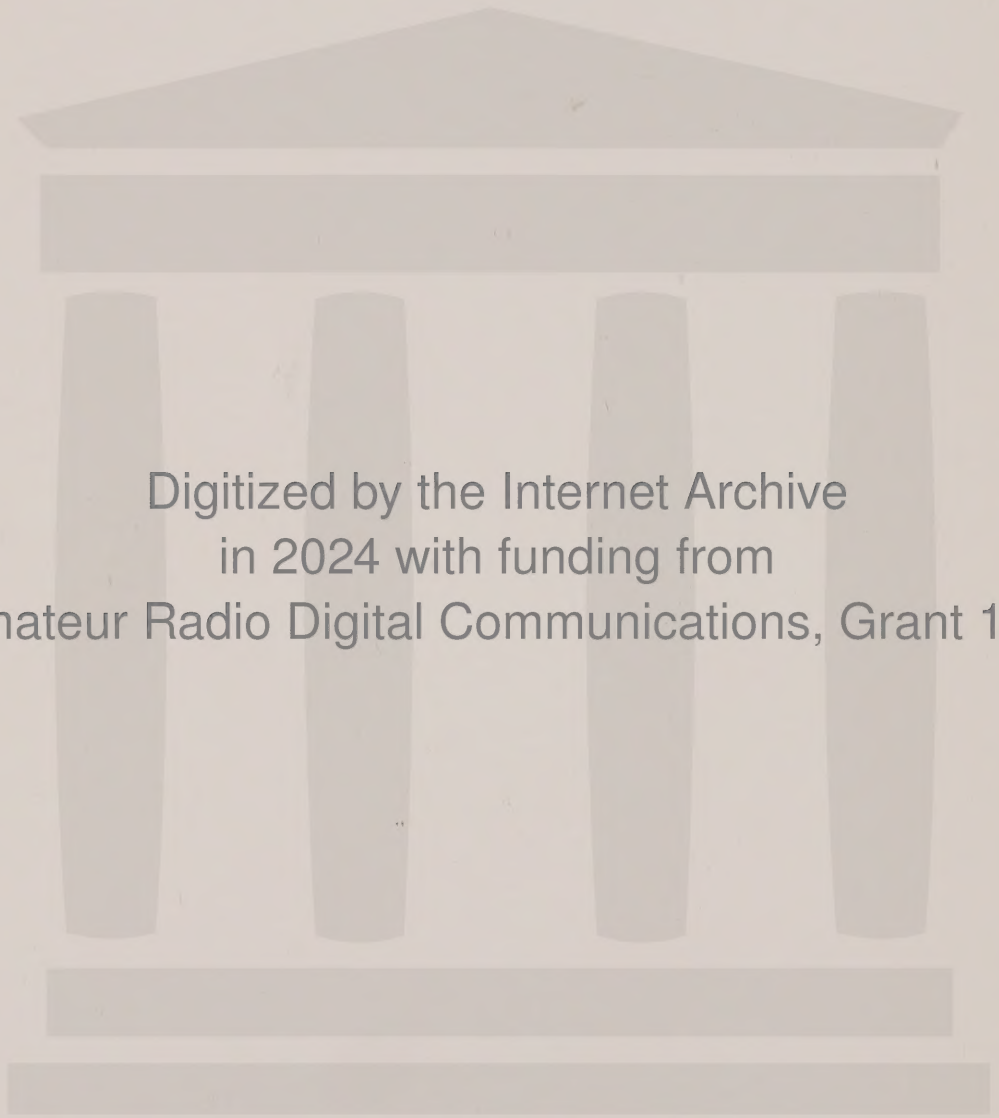
THE PRACTICAL GUIDE TO SATELLITE TV

Second Edition



by Garry Cratt



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Preface

Despite the increasing interest in satellite TV, information on the subject continues to be scarce. Like the personal computer in 1980, satellite TV is often thought to be the sole domain of scientists, engineers, and techno "freaks".

Nothing could be further from the truth. Satellite TV reception is perfectly straight forward and can be embraced by anyone interested enough to learn.

This book is the proof. Written by someone with few formal qualifications, every subject covered is the result of hands on experience and the subsequent logical explanation.

Deliberately omitted from this book are complicated mathematical calculations, scientific jargon, and the pages of irrelevant footprints, sometimes encountered in other texts. Included are practical answers to all aspects of satellite television reception for our part of the world.

As satellite TV expands, the world shrinks. Perhaps this book will help you to be part of this growing industry.

Acknowledgements

I would particularly like to thank the following, who unwittingly played an important part in making this book possible. Vic Barker, who introduced me to satellite television in its infancy in the late 1970's. Dick Smith, for providing me with the opportunity to visit and research satellite television in overseas countries. Bob Cooper, who influenced me during the 1980's with his outspoken satellite publications and continues to do so today, Fraser Hickox for his constant support, Lindsay Jorgensen who pioneered commercial satellite TV reception in PNG, Anne Ames who, through Orbit International magazine, opened my eyes to the international appeal of satellite TV reception, and the hundreds of customers who have provided feedback and support since 1990.

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About the author

Garry Cratt trained at AWA Research and Development, prior to an 11 year career at Dick Smith Electronics. He has written numerous articles for electronics magazines over the last 10 years, and is now Technical Director of AV-COMM Pty Ltd.

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PRINCIPLES OF OPERATION

Geostationary orbit, Non geostationary orbit, the space segment: ITU Regions, atomic power, satellite transponders, the uplink: earth station configuration, uplink security, the downlink: beams, footprints, link budget calculations: EIRP, path loss, rainfall, availability, commercial software.

EARTH STATION COMPONENTS

Dishes: types, materials, construction techniques, gain, noise temperature, sidelobes, offset, flat antennas. Feedhorns: focal point, E & H fields, scalar feed, moded feed. Polarisers: magnetic, mechanical, orthomode. LNB's: theory, calculating IF frequencies, waveguide, noise temperature, L.O. stability, PLL, wideband, integrated with feedhorn, one cable solution. Dish mounts: ground, Az/El, polar, horizon to horizon. Actuators: acme, ball screw, limit switches, controllers, Robot positioner, actuator cables. Coaxial cables: attenuation, connectors. Weather proofing: self amalgamating tape, LNB covers. Line amplifiers, splitters, polarity switches, 22KHz switch. Receivers: SAW filter, C/N v S/N, low threshold, SCPC, baseband services. Internet: sites.

ENCRYPTION SYSTEM

Videocrypt, Cryptovision, Vidiplexing, BMAC, E-PAL, Sinewave sync shifting.

VIDEO COMPRESSION

MPEG 1, MPEG 2, "Direct TV", DVB compliance, Conditional Access, digital IRD architecture, bit error rate v CCIR

SETTING UP A SATELLITE TV RECEIVING SYSTEM

Preparatory work: satellite selection, list of visible satellites, dish pointing, look angles for Optus, WACs, ONCs. Siting the dish: site survey, troublesome sites, local council regulations. Dish alignment: finding true north, declination, alignment tools, dish Az/El, LNB polarity, focal point, checking operation, antenna pointing program, signal meters. Inclined orbit satellites: the Comsat manoeuvre, saving fuel, bushes and bearings, predicting orbital location using 2 line elements, trackers: single and multi-satellite models. Multiple satellite systems, dish location, mounting, multi polarity requirements. International video standards: NTSC, PAL, SECAM, digital converters. Wiring the system: external, internal, SCART, connections, RF combiner. Maintenance. Solar outages: theory, predictions.

GLOSSARY OF TERMS

APPENDIX

All satellite footprints falling on any part of Australia.

Satellite data for orbital locations:

185.7°E	183.0°E	180.0°E	177.0°E	174.0°E
169.0°E	166.0°E	164.0°E	160.0°E	156.0°E
152.0°E	150.5°E	150.0°E	148.0°E	146.0°E
145.0°E	140.0°E	139.0°E	138.0°E	134.0°E
128.0°E	122.0°E	118.0°E	113.0°E	108.0°E
107.7°E	105.5°E	103.0°E	100.5°E	96.5°E
93.5°E	91.5°E	90.0°E	85.0°E	83.0°E
80.0°E	78.5°E	76.5°E	72.0°E	68.5°E
66.0°E	64.0°E	62.0°E	60.0°E	57.0°E
53.0°E				

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Brief History of Satellite Development

The concept of satellites orbiting the earth as spaceborne repeaters, was first proposed by Arthur C Clarke in the October 1945 edition of Wireless World magazine. He envisaged three satellites, orbiting at the same rotational velocity as the earth, acting as giant relay stations, far above the earth.

The first man made satellite launched into orbit was the Russian "Sputnik 1" in October 1957. It circled the earth in a low polar orbit that required constant tracking adjustments to receive the morse code signal it transmitted. Later, in December 1958, the US Air Force launched a satellite named "Score" which transmitted a prerecorded message from the US President. It too was launched into a polar orbit.

The world's first geostationary satellite was designed and built by the Hughes Aircraft Corporation in 1963. It was called "Syncom" and had the capacity to relay either a single TV channel or 50 separate telephone conversations from its orbit high above the equator between Africa and South America. This position allowed it to relay the first real time TV transmissions between North America and Europe. By 1965 the scientific community had realised that TV signals could be easily distributed over vast distances by using satellites in geostationary orbit as relay stations.

In 1966, the International Telecommunications Satellite Organisation (Intelsat) launched "Early Bird" into geostationary orbit over the Atlantic Ocean. It had the capacity to transmit 240 voice circuits or a single TV signal. But, partly because it employed an omni directional antenna, a large proportion of the available energy was radiated in directions where it could not be used. In order to keep the satellite antenna oriented in the correct plane for transmitting towards earth, the cylindrical body of Intelsat 1 was spun on its axis at a fixed rate. This "spin stabilisation" technique was subsequently used by most other satellites.

In 1965 the USSR had launched a domestic satellite communications system called Molniya (Russian for lightning). It connected isolated villages and towns throughout the Soviet Union with radio and television broadcasts originating from Moscow. But, instead of using a geostationary orbit, the Russians deployed several satellites in elliptical orbits around the earth. As a result, ground stations had to constantly track the satellite as it passed overhead.

TABLE OF SIGNIFICANT DATES IN SATELLITE HISTORY

1957	October 4	Sputnik 1 launched	First Satellite in space
1958	February 1	Explorer 1 launched	First US Satellite in space
	December 18	Score launched	First telecommunications Satellite
1959	October 13	Explorer 7 launched	First meteorological Satellite
1960	October 13	Explorer 8 launched	First NASA Satellite in space
1962	February 24	Echo 1 launched	First TV broadcast by Satellite
	April 26	Ariel 1 launched	First UK Satellite in space
	July 10	Telstar 1 launched	First commercial telecommunications Satellite
	September 29	Alouette 1 launched	First Canadian Satellite in space
1964	August 19	Syncom 3 launched	First geostationary telecommunications Satellite.
	December 15	San Marco 1 launched	First Italian Satellite in space
1965	November 26	Asterix launched	First French Satellite in space
1967	November 5	ATS-3 launched	First geostationary meteorological Satellite
	November 29	Wresat launched	First Australian Satellite in space
1968	May 17	ESRO 2B launched	First European Satellite in space
	November 8	Azur launched	First German Satellite in space
1970	February 11	Ohsumi launched	First Japanese Satellite in space
	April 24	Dong Fang Hong 1 launched	First Chinese Satellite in space
1974	August 30	ANS launched	First Dutch Satellite in space
	November 15	Intasat launched	First Spanish Satellite in space
1975	May 19	Aryabrata launched	First Indian Satellite in space
1976	July 8	Palapa A1 launched	First Indonesian Satellite in space
1978	October 24	Magion 1 launched	First Czechoslovakian Satellite in space
1981	August 7	Intercosmos Bulgaria 1300 launched	First Bulgarian Satellite in space
1984	April 6	SMM Shuttle launched	First Satellite repair in space
	November 16	STS 19 launched	First Satellite returned to earth for repair
1985	February 8	Brazilsat A1 launched	First Brazilian Satellite in space
	June 17	Morelos 1 launched	First Mexican Satellite in space
1986	February 22	Viking launched	First Swedish Satellite in space
1988	September 19	Offek 1 launched	First Israeli Satellite in space
	December 11	Astra 1 launched	First Luxembourg Satellite in space
1990	January 22	Lusat launched	First Argentinian Satellite in space
	July 16	Badr A launched	First Pakistan Satellite in space
1992	August 10	Kitsat A launched	First S.Korean Satellite in space
1993	September 25	Posat launched	First Portugese Satellite in space
	December 18	Thaicom 1 launched	First Thai Satellite in space
1994	August 10	Turksat 1B launched	First Turkish Satellite in space
1995	August 31	Sich 1 launched	First Ukranian Satellite in space
	August 31	Fasat Alfa launched	First Chilian Satellite in space
1996	January 12	Meast 1 launched	First Malaysian Satellite in space
1997	August 19	Mabuhay 1 launched	First Philippine Satellite in space

Source: The Satellite Encyclopedia

The Molniya orbit had a high northern apogee (usually around 40,000km), resulting in a reduction in the orbital velocity as the satellite travelled away from earth. The effect of this orbit, was to place the satellites over northern regions for a longer period of time (compared with a geostationary orbit), in precisely the area where most coverage was needed. The normal orbital period of these satellites was 12 hours, meaning that they were non-synchronous with the rotation of earth.

Today the Molniya system has been replaced with a fleet of 10 Gorizont and 1 Express satellites covering the major populated areas of the world. These satellites are operated by the Russian Space Agency, formed after the breakup of the former Soviet Union, and the dissolution of the former Soviet Space program.

The RKA uses technology and launch sites that belonged to the former Soviet space program. At present, the RKA has centralised control of Russia's civilian space program including all manned and non manned non military space flights.

Most Gorizont satellites presently in orbit were launched using the 4 stage Proton medium lift launcher, first introduced in 1965.

By the late 1960's Intelsat had devised a system where spin stabilised satellites were given orbital assignments over the Atlantic, Pacific and Indian Oceans to cover the entire globe. By this time the telephone capacity had been increased to 1500 simultaneous voice circuits and 1 TV circuit. In addition, these satellites carried directional antennae so that the full available power was radiated towards earth.

Subsequent Intelsat satellites developed in the 1970's carried steerable spot beam antennas which were able to concentrate transmitted energy into powerful beams on desired areas of the globe. The capacity had been progressively improved and by 1975, 3750 telephone circuits and 2 TV channels could be carried simultaneously.

Intelsat currently employs a constellation of 24 orbiting satellites.

The latest series of Intelsat satellites allows provision of over 80,000 telephone channels, and satellites now have a lifetime of 7 to 15 years.

International operation of Intelsat satellites occurs in four main areas, the Atlantic Ocean Region (AOR), the Pacific Ocean Region (POR), the Asia Pacific Region (APR) and the Indian Ocean Region (IOR).

The Atlantic Ocean Region serves most of the Americas, Western Europe, India and all of Africa. Satellites in this region provide operational coverage from 222°E to 84°E.

The Indian Ocean Region serves eastern Europe, Africa, the Middle East, India, South East Asia, Western Australia and Japan. Satellites in this region provide operational coverage from 332°E to 151°E.

The Asia Pacific Region serves Eastern Europe, Russia and the other CIS countries, all of Asia from India to Japan and Australia. Satellites in this region provide operational coverage from 6.5°E to 176.5°E.

The Pacific Ocean Region covers South East Asia, Australia, the Pacific and Western parts of Canada and the USA.

Traffic is highest in the AOR, almost double that in both the POR and IOR, and lowest in the new APR. Intelsat policy is to provide multiple operational satellites in the AOR, IOR, APR and POR. In addition, there is one in orbit spare, or "backup" satellite in

each region. From time to time in orbit spare satellites are allowed to "drift" to alternative locations to replace earlier, and ageing satellites.

In addition to Intelsat and the Russian series of spacecraft, there are a number of privately owned companies operating satellites around the world. Panamsat is a privately owned satellite company with spacecraft covering the POR, IOR, and Latin America. The company has plans to expand to 8, the number of operational satellites around the world.

Another operator, Orion Network Systems, plans to have three high power international satellites operational by the end of 1999.

To be located at 12°W,37.5°W and 139°E, these three high power satellites will provide coverage to approximately 85% of the worlds population.

In Australia, Optus Communications owns and operates 4 geostationary satellites: Optus B1, A3, B3 and A2. These satellites provide Homestead and Community Broadcasting Services (HACBSS) to remote areas, Interchange links for commercial TV networks, commercial services such as SKY Channel, Q-Net, Golden West Network, Imparja TV, Galaxy MPEG Pay TV, FM2 services for NTM and 4TAB radio stations, and many digital radio, and data services.

The A series spacecraft have now been replaced by the B series spacecraft, which have higher power capability and tighter footprints.

The 1998 World Satellite Yearbook lists 256 operational satellites distributing television and radio around the world.

TVRO (TV receive only) history is short. Prior to 1975 there was simply no private reception of satellite TV signals.

Electronics enthusiasts and amateur radio operators have long played an important role in the development of TVRO systems. In 1975 a British experimenter, Steve Birkill pioneered the construction of home made dishes, microwave amplifiers and receivers for satellite TV reception. In the USA, enthusiasts Bob Cooper and Taylor Howard were busy developing techniques and modifications to allow surplus military equipment to be pressed into service, and consequently, a group of 30 or so radio amateurs began the "Home Satellite TV" industry in the UK and USA. The 1980 issue of the American magazine "Radio Electronics" featured a series of instructional articles, showing the progress made by radio amateurs in pursuit of this new hobby.

Australia has its pioneers too, like Vic Barker VK2BTV, who pioneered the reception of Intelsat 3 in the mid 1970's using low threshold techniques the experts thought impossible. In 1980 another Australian enthusiast, Fraser Hickox and American Taylor Howard formed an alliance to bring the first satellite TV signals to the general public in outback Australia. They constructed huge spherical antennas to receive Intelsat 4, bringing the American Armed Forces TV and Radio Service (AFRTS) and the Australian ABC to outback residents.

These signals were subsequently terrestrially re-

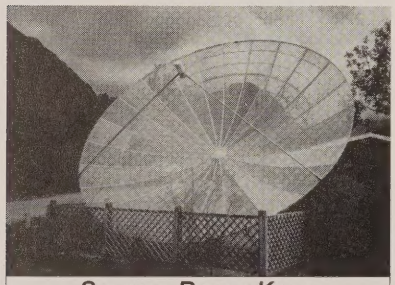
Courtesy: Electronics Australia

broadcast by VHF transmitters, located at remote communities. Later, the huge spherical antennas were replaced with more manageable 3.7m fibreglass dishes, produced in Brisbane. Hundreds of these dishes served remote communities and homesteads until the successful launch of the first Aussat satellite in 1985.

In New Zealand, the first

large TVRO dishes were manufactured and installed in the South Cantebury area by Gary Fogarty in 1983. The sole source of signals came from the Intelsat "bird" at 180° east. As the government run VHF terrestrial TV service operated a single channel for very few hours each day, a market soon emerged for the supply of C band equipment capable of bringing AFRTS and several US network feeds into homes and motel rooms across New Zealand and the "nearby" Chatham Islands, 600 kilometres away!

Roger Keen, another pioneer, installed numerous



Source: Roger Keen

tracking systems at isolated mountain resorts along the West coast, and around New Zealand, and in 1989 installed the first re-transmission system for satellite TV signals on the Chatham Islands, still in use today.

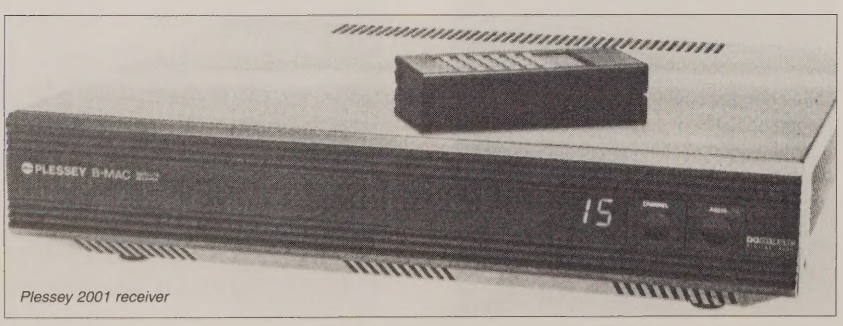
In July 1985, after successfully evaluating reception from an early "Anik" satellite, (moved from its orbital assignment over Canada for several weeks of testing), Australia launched Aussat A1, a Hughes 376 spacecraft with 15 transponders, to be used for television distribution across Australia and New Zealand.

Subsequently, Aussat A2 and A3 satellites were launched in November 1985 and September 1987 to cater for additional demand and future expansion.

Early DBS systems used a 3m dish, 2dB (noise figure) LNBs and a B-MAC receiver, locally produced under license from Scientific Atlanta by Plessey Australia. At an installed cost approaching $3000, such a system was capable of delivering two channels of TV radio programming. Understandably, at that time the high price was a daunting prospect, and sales were conservative.

In total, some 18,000 Plessey-BMAC receivers were sold into the outback and nearby Pacific island markets, such as Norfolk and Lord Howe Islands, New Guinea, New Zealand, Samoa, and New Caledonia.

Although the B-MAC delivery system is due for retirement by January 1999 (to be replaced with an MPEG-2 service), a Plessey 2001 receiver still commands a substantial price today. The replacement unit, purchased out of necessity when Plessey discontinued manufacturing in the mid 1990's, came from Canadian company Scientific Atlanta, the original license holder of the proprietory BMAC system.



Plessey 2001 receiver

The 625 line BMAC receiver, model 9708 was substantially larger than its predecessor, was rack mounted, and had no remote control facility. In addition, the radio services that were accessible in a standard 2001 receiver, required an additional audio decoder board to be fitted to the #9708, costing around $600.

In 1991, several companies began to market a K band system, capable of receiving the PAL interchange signals on the Aussat A1 satellite. Although these signals are not designed to be received by backyard enthusiasts, technology had improved to such an extent by that time, that a 1.6m dish could be used. Several thousand systems were sold, opening both a new world and a new market of satellite enthusiasts.

Now, private individuals whose terrestrial television reception was poor or non existent, had an additional source of entertaining "signals", despite their fortuitous nature.

In other parts of Australia, C band signals from international satellites were becoming available from several Russian "Gorizont" spacecraft,and the Indonesian Palapa B2P satellite.

Intelsat also increased the number of operational satellites in the POR (Pacific Ocean Region) to 4, resulting in an increase in occasional signals for enthusiasts, in all parts of Australia, not just the far north.

In July 1995, Panamsat launched the PAS-2 satellite covering the Pacific Rim, initially providing up to 5 analogue and fortuitous, but FTA (free to air) signals, capable of being received all over Australia using dishes in the 1.8m to 2.3m range.

In November 1995, Asiasat 2 was launched, covering Australia with C band signals strong enough to be received using dishes down to 1.8 m.

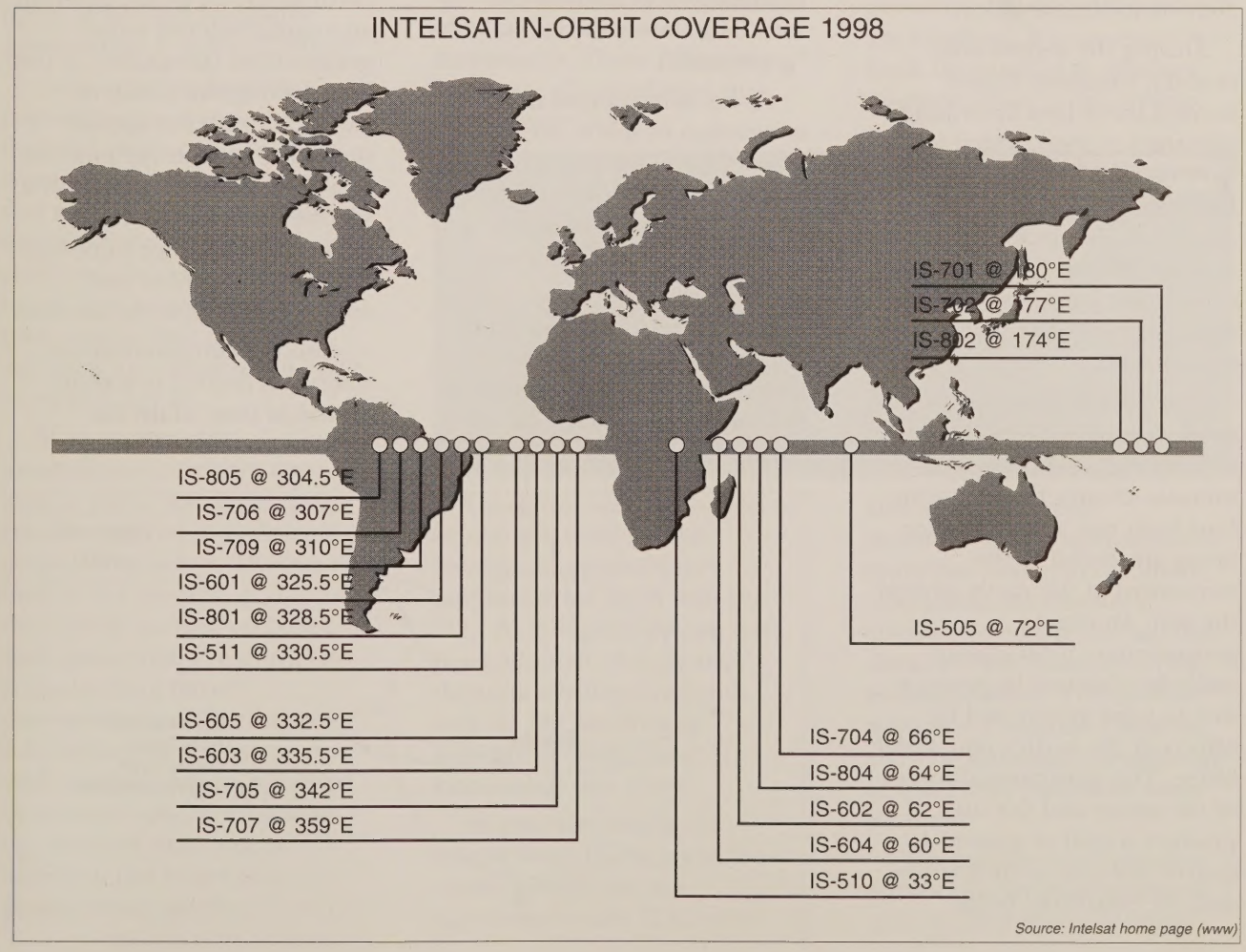
On February 15 1996, Palapa C1 and subsequently Palapa C2 were launched as replacement satellites for Indonesia. These satellites also cover Australia and New Zealand, providing up to 20 'fortuitous' signals for enthusiasts.

In March 1998 an independant arm of Intelsat, called New Skies Satellites N.V. was created to commercially maintain and operate several Intelsat satellites.Initially those satellites will be Intelsat 513, 703, 803, 806, and K-TV.

In summary, since 1985, the number of satellites visible to Australia has increased to over 10, resulting in increasing interest in home satellite TV reception. Often, satellite signals are broadcast in foreign languages (NHK Japan, RTPI Portugal, Deutsche Welle Germany, CCTV4 China, RFO Tahiti, TV3 Malaysia), making them an important source of programming to immigrants and language students.

Presently there are over 125 separate satellite signals (some are regular scheduled broadcasts) in most languages of the world available to satellite enthusiasts.

Over the next few years, more satellites have been ordered for coverage of the Asia Pacific Region than any other region of the world.



Principles of Satellite Operation

Geostationary Orbit

A geostationary satellite is one which remains above the same spot on the earth as it orbits. This means that the time taken for a geostationary satellite to complete one orbit in space is the same time as the time taken for earth to rotate once on its axis. It also means that the satellite orbits in the same direction as the rotation of the earth.

This is the most widely used type of satellite orbit because elaborate tracking systems are not required. The geostationary orbit lies directly above the equator, and the distance above earth that the satellite must reach to remain in geostationary orbit is about 36,800km (22,280 miles).

During the seventeenth century, Johannes Kepler derived three laws describing planetary motion, which were later verified by Newton. Basically, Keplers laws apply to any two bodies in space that interact through gravity. These laws set the parameters under which geostationary orbit can be achieved.

The period taken for a geostationary orbit is 23 hours 56 minutes. This is about 4 minutes shorter than a twenty four hour day, the difference being attributed to the movement of the earth around the sun. An exact geostationary orbit cannot easily be obtained in practice due to solar gravity and the effects of the earth's equatorial bulge. The gravitational forces of the moon and the sun produce a shift of around 1 degree per year in inclination, and the equatorial bulge causes a drift in an easterly direction. As the earth is not perfectly circular in the equatorial plane, there is a small eccentricity, in the order of 10^{-5}, called the "equatorial ellipticity".

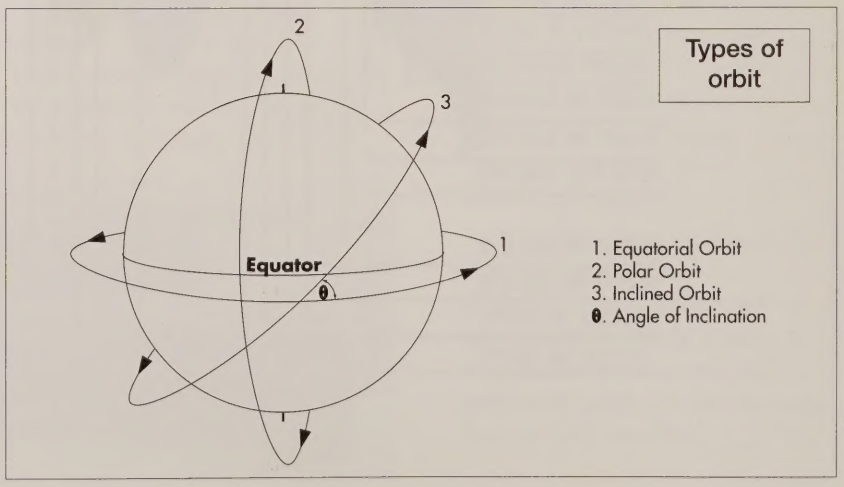
The effect of all this is to cause a gravity gradient affecting orbiting satellites. The gravity gradient causes geostationary satellites to drift to one of two stable points, which coincide with the minor axis of the equatorial ellipse. These two points are separated by 180 degrees and lie at approximately 75 degrees east and 105 degrees west longitude. Old satellites, out of service, and without the benefit of station keeping fuel, eventually drift to these two locations known as satellite "graveyards".

As an indication of the congestion in space, the US Space Command routinely tracks over 8000 objects over 10cm in diameter, and over 400,000 pieces of debris over 5cm in diameter.

A satellite remains in orbit because the centripetal force caused by its rotational velocity is counter-balanced by the earth's gravitational pull. The closer the satellite is to the earth, the greater the gravitational pull and hence the higher the velocity required to keep the satellite in orbit. Geostationary satellites travel at 11,000km per hour with a rotational period of 23 hours 56 minutes, the same as that of the earth. Lower altitude satellites (160km to 450km) travel at approximately 28,000km per hour and take approximately 1.5 hours to circle the earth. Medium altitude satellites (9,000km to 19,000km) have rotational intervals of 5 to 12 hours.

Non synchronous satellites rotate in low altitude, elliptical or circular patterns, with the earth as a focal point, and with an angular velocity either greater than (prograde) or less than (retrograde), that of earth. They do not appear stationary in their sky position to a fixed point on the earth's surface and therefore expensive tracking equipment is required to follow and communicate with the satellite.

Also the communications interval is limited to a short period of time whilst the satellite remains within



reasonable viewing angles and tracking limits.

The primary advantage of a geostationary satellite, is that it remains almost stationary with respect to a given point on earth and consequently tracking equipment is not required.

High altitude geostationary satellites can cover a much larger area of the earth's surface than low orbiting types, and hence three geostationary satellites can cover 90% of the entire globe.

There are, however, some disadvantages. High altitude geostationary satellites introduce noticeable propagation delays due to the distance that signals must travel. A two-way telephone conversation is delayed 500mS.

Geostationary satellites require higher transmit powers than the lower polar orbiting types, requiring larger battery and solar cell capacity, limiting the life of the spacecraft. In addition, greater transmission losses associated with a longer path, ensure that large dish antennas are required on earth to receive signals.

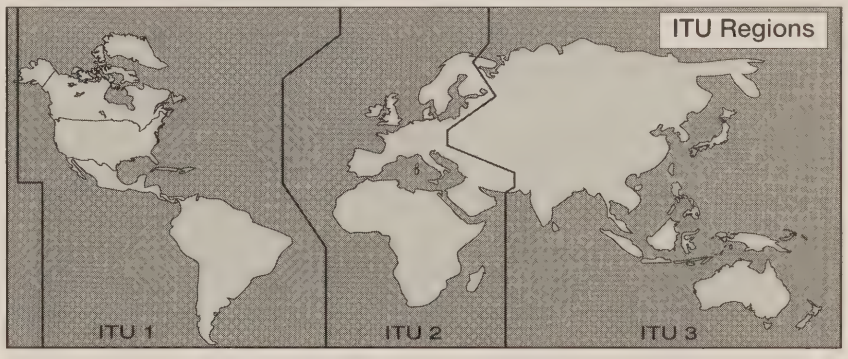
Most importantly, geostationary satellites must be kept in orbit. Station keeping requires the use of hydrazine propulsion rockets. There is a limit to the amount of this fuel that can be carried on board each spacecraft. Presently, this is the limiting factor determining satellite lifetime. It is unlikely in the future that such satellites will be refuelled by manned spacecraft due to the distance that must be travelled, just to get to a geostationary satellite.

The Space Segment

There are two commonly used bands for downlinking satellite TV signals. C band (3.4-4.2GHz) and K or Ku band (10.95-12.75GHz). These

MICROWAVE BANDS	
BAND	FREQUENCY
L	1.53GHz – 2.7GHz
S	2.5GHz – 2.7GHz
C	3.4GHz – 4.2GHz
X	7.25GHz – 8.4GHz
Ku	10.7GHz – 14.5GHz
K	17.7GHz – 21.2GHz
KA	27.5GHz – 31.0GHz

bands are geographically set by international convention. The world has been divided into three separate regions, by the ITU (International Telecommunications Union) for the purposes of allocation of all radio (and satellite) frequencies. These frequency bands are allocated on a non interference basis.



Countries wishing to reserve orbital positions for the location of geostationary satellites must do so with the ITU. As 2 degree spacing has been adopted, this means theoretically there can only ever be 180 satellites in separate geostationary locations at one time.

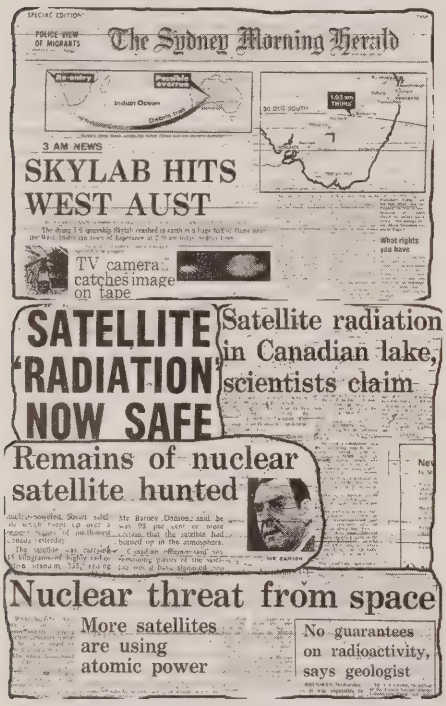
In practice, this is not strictly true. There are many countries who are not signatories to the ITU, who have launched and positioned satellites at orbital locations without any consultation with other satellite operators or the ITU. Also, it is often possible to co-locate more than one satellite at the same orbital position. The satellites remain some distance apart (perhaps one tenth of a degree), but the "nominal" orbital location is the same. On board spacecraft radar, and tight ground control can allow as many as 4 satellites to be co-located at the same nominal orbital location.

At present there are almost 500 geostationary satellites in orbit, although not all are used for television delivery services.

In order to keep a satellite in operation, considerable ground based support services are required. It is necessary to track the satellite at all times, monitor power consumption and other electrical parameters, and approximately every two weeks, to command changes to the satellite altitude, to ensure the satellite does not drift from its correct orbital position. The satellite transmits a telemetry beacon, allowing automatic monitoring of spacecraft condition, and location.

The satellite itself requires significant electrical power to operate, and this is normally

provided by solar panels, either telescoping cylindrical units or panels that are stowed during launch and which unfold after final orbit has been attained. The spacecraft batteries are normally nickel


The Sydney Morning Herald
3 AM NEWS
SKYLAB HITS WEST AUST
TV camera catches image on tape
SATELLITE RADIATION NOW SAFE
Satellite radiation in Canadian lake, scientists claim
Remains of nuclear satellite hunted
Nuclear threat from space
More satellites are using atomic power
No guarantees on radioactivity, says geologist

Source: Mitchell Library microfilm

hydrogen types, due to their superior power to weight ratio, although until the mid seventies, nickel cadmium batteries were used.

Most Russian satellites are high powered models, and derive their energy source from an on board atomic reactor. This approach is not officially favoured by Western countries, due to the increased risk encountered upon spacecraft re-entry and consequent disintegration, at the end of the spacecraft life. In 1978, an atomic powered Russian military satellite, Cosmos 954 re-entered the earth's atmosphere, suffered partial disintegration and leaked radioactive material over northern Canada. On July 11 1979, a large lump of the US Skylab space station crashed in outback Australia during re-entry into the earth's atmosphere.

Satellite Transponders

All satellites carry a number of individual repeaters comprising an uplink receiver, coupled to a transmitter for downlinking. This combination is called a transponder. Most satellites carry 15 or 24 transponders, which may be connected and cross connected to a number of directional dish antennas on the spacecraft, which point towards earth, targeting various areas with signal beams. The most commonly encountered beams are global, covering a large area with reduced signal intensity, and spot beams which cover specific areas with higher powered signals. Figure 1a/b shows the difference between "national" or "global" beams and "spot" beams carried on the Optus B1 spacecraft.

The group of transponders normally operates in a 500MHz wide band, divided into sub-bands, one per transponder. Thus a satellite covering a band 500MHz wide could only accommodate 12 transponders having the required bandwidth of 36MHz each for television quality signals.

As there must also be a "guard" band of 4MHz between adjacent transponders to ensure no interference, this reduces the transponder

OPTUS GDL CONTOURS: EIRP (dBW)
Series: B Beam: National

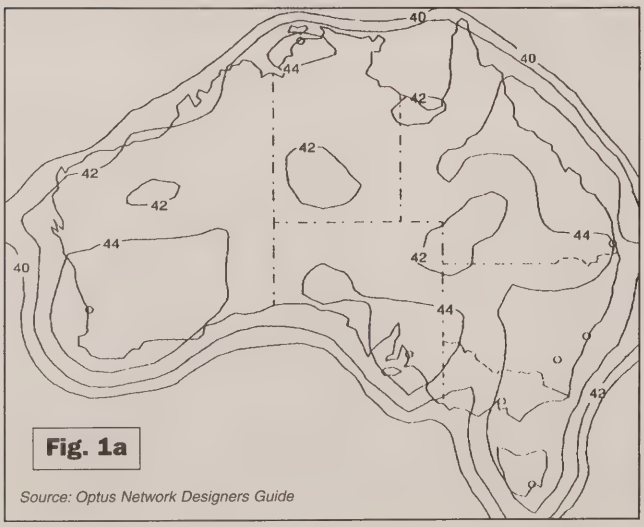


Fig. 1a

Source: Optus Network Designers Guide

OPTUS GDL CONTOURS: EIRP (dBW)
Series: B Beam: NE

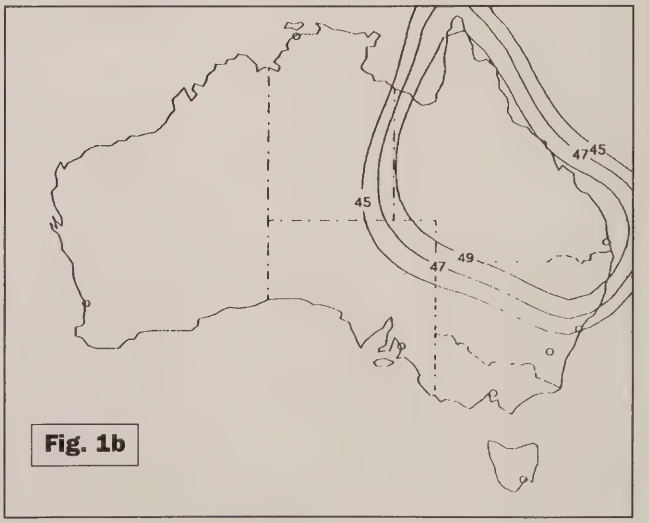
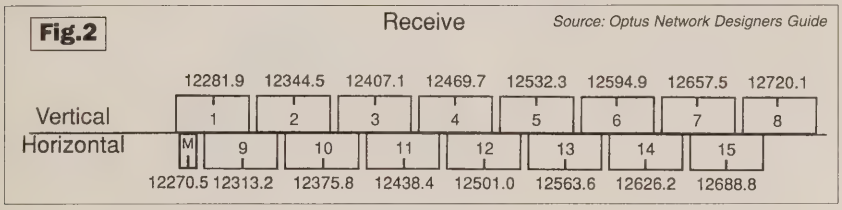


Fig. 1b

capacity even further. However, due to a frequency re-use technique using polarisation isolation, it is possible to accommodate 24 transponders, each 36MHz wide. Each adjacent transponder uses the opposite polarity. Figure 2



shows the transponder arrangement on the "B" series of Optus K band spacecraft.

Spacecraft C band uplink receivers operate on 6GHz, whilst K band receivers operate at 14GHz. There is considerable redundancy and duplication of equipment on board the spacecraft, to allow ground stations to reconfigure the transponder switching arrangements in the event of a hardware failure.

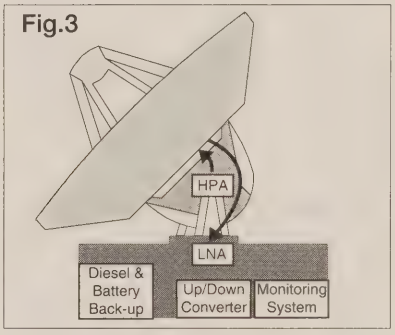
Unlike terrestrial television, the transmission mode used by satellites for television, is FM (for both vision and sound). FM is a transmission mode that requires a much lower amount of DC power when compared to AM, but does require a much wider bandwidth. So from the point of view of minimising spacecraft power usage, it makes sense to use FM. However, one of the problems found when using FM for this purpose, is that if the spaceborne FM transmitter were allowed to remain on a single frequency for any appreciable time, interference would be generated to earth based services. This is easy to imagine considering the EIRP of the average C band satellite is 2.5KW.

To ensure this kind of frequency interference can never be generated, a technique known as "energy dispersal" is used. A sawtooth waveform is added to the video signal, and is synchronised to the field frequency, sweeping the video signal. An NTSC 525 line 60Hz signal uses a 30Hz energy dispersal signal, and a 625 line 50Hz PAL TV signal uses a 25Hz energy dispersal signal. If the television signal occupies a full transponder, the dispersal level is held at 1MHz peak to peak deviation. If half transponder operation is used, the same dispersal level is used when video is present. When no video is present the level is increased to 2MHz peak to peak.

This technique is particularly effective in eliminating interference, and is even used on terrestrial microwave link systems. The energy dispersal waveform is removed in a satellite receiver by clamping the video. The baseband output of most satellite receivers contains unclamped and unfiltered video, and the effect of energy dispersal can be seen by connecting a video monitor to this output. Noticeable flickering of the video signal can be usually observed.

The Uplink

The design of the uplink is significantly easier than the downlink since it is much easier to produce high power levels at ground based earth stations, than on a spacecraft. However the construction of an uplink station is a costly exercise, as the generation of high stability, spurious free, microwave signals is expensive. In addition, larger dishes have a narrow beamwidth, so careful mechanical control of the dish is essential. If a smaller dish is used at the uplink, higher power levels must be generated to overcome the reduction in dish gain. Figure 3 shows the typical configuration of an uplink station.

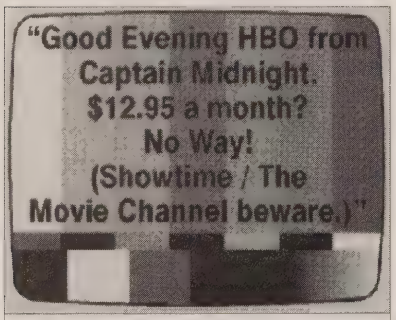


A typical uplink earth station comprises a dish antenna, feeder system, diplexer, transmitting electronics, transmit high power amplifier, a downlink monitor receiver, a tracking system and auxiliary systems required for power including generator back up, temperature control and antenna de-icing if necessary. In addition there must be the interface circuitry between local microwave or optical fibre interconnects and the switcher controlling the transmitter.

Because a fixed uplinking station has the ability to transmit large amounts of microwave power into space, particular care must be taken to ensure that interference is not caused to adjacent satellites.

An incorrectly aimed uplink could completely disrupt the services on an adjacent satellite. As the information transmitted to the satellite will subsequently be rebroadcast to potentially thousands of earth stations, a strict criteria for staff selection is employed.

In April 1986, an uplink operator, in Florida, USA calling himself "Captain Midnight", overrode an existing uplink program to broadcast his own message to viewers across mainland USA, protesting proposed scrambling of the HBO movie channel. Due to the amount of uplink power at his disposal, he was able to completely obliterate the legitimate uplink signal on several occasions. He was finally tracked down through a unique fault in the character generator at his uplink station.



Courtesy: Bob Cooper

Modern satellites require an encrypted security code to be transmitted to ensure only legitimate uplink stations have access.

The Downlink

Equipment configured for reception of satellite signals on earth must take into account the satellite transponder power, bandwidth, and spacecraft antenna "footprint".

Each transponder can be connected to one of several spacecraft antenna. Each antenna has a separate "beam". A global beam is capable of covering up to 40% of the surface of the earth, whilst a spot beam can be concentrated on a specific area. Uplink operators can connect a particular transponder to a particular antenna. They can also move the satellite antenna to change the coverage area.

The amount of power transmitted by a particular transponder is dependent on the uplink power to that transponder. Portable news gathering links with small antennas, can only operate at low power levels, so the corresponding satellite downlink will be low in power, requiring a large major earth station antenna. A fixed uplink station is designed to deliver the correct amount of power to the satellite to ensure optimum downlink power. During times of heavy rain or snow, (which can attenuate both the uplink and the satellite downlink) the uplink transmitter must have sufficient power reserves to increase power to overcome the increase in path loss.

Link Budget Calculations

Due to the limited downlink power of the satellite, and the distance the signal must travel (and the corresponding "path loss"), it is important to select earth station components capable of producing a signal above threshold, for processing by the satellite receiver.

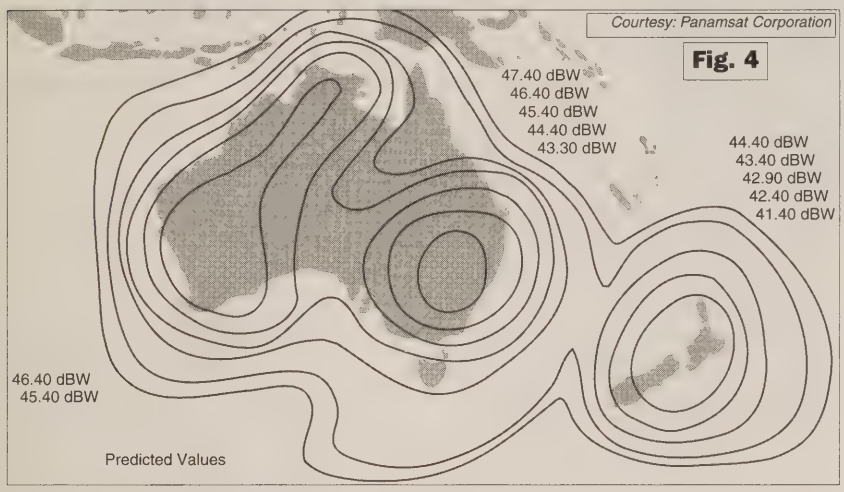
The two most important factors affecting the signal are the dish gain, and antenna/LNB noise temperature. To calculate the required performance of these two items, we must first know the level of the signal from the satellite as it falls on earth.

As satellites are designed to cover specific areas on earth, a signal contour map is produced by the satellite owner, showing the signal levels that can be expected from the satellite at particular locations on earth. Such a contour map is called the signal "footprint". A footprint looks like a number of concentric circles, similar to the pattern generated when a pebble is thrown into a still pond. The circles closest to the centre have a higher energy level than the outer circles.

Figure 4 shows footprint of the PAS-2 satellite. Note the higher strength signal contours closer to the centre or "boresight".

The satellite EIRP (effective isotropic radiated power) can be read directly from the footprint. The ERIP contours are measured in units called the "dBw". A satellite output level of 20 dBw means that the power level of signal leaving the spacecraft downlink antenna is equal to 20dB , or 100 times one watt. This figure is the product of the output power of the satellite transponder and the gain of the particular spacecraft antenna being used. Even if

the footprint contours indicate a signal level of 50dBw, the amount of power actually reaching the surface of the earth (considering an average path loss of 200dB) is minute.



An analysis of the conditions affecting the loss of signal from spacecraft to earth, based on the EIRP, and the gain of the receiving antenna/LNB/feedhorn system, will then give us an indication of the C/N ratio (carrier to noise) arriving at the satellite receiver input. The C/N ratio directly affects the video signal to noise (S/N) ratio produced by the satellite receiver.

This video S/N ratio itself means little to the consumer, so a subjective 5 point scale, called the CCIR scale has been devised, as follows:-

Quality	Attributes	S/N
Excellent(5)	Noise free	46dB
Good(4)	Minimal Noise	42dB
Fair(3)	Noticable Noise	38dB
Poor(2)	Annoying Noise	33dB
Bad(1)	Very annoying	29dB

One of the main factors affecting the attenuation of signal from spacecraft to earth is the free space path loss. Fortunately, this data is freely available, as can be seen in Fig 5a. In addition to this loss, the effects of rain need to be addressed.

In general terms, the higher the frequency, the worse the effect of rain on a satellite signal. Rain attenuation is worse at 12GHz than at 4GHz, and also affects the 6GHz and 14GHz uplink bands. In order to compensate for the worst case of rain attenuation, to guarantee 100% reception reliability, the system designer might have to incorporate an extra 20dB of performance margin into an earth station.

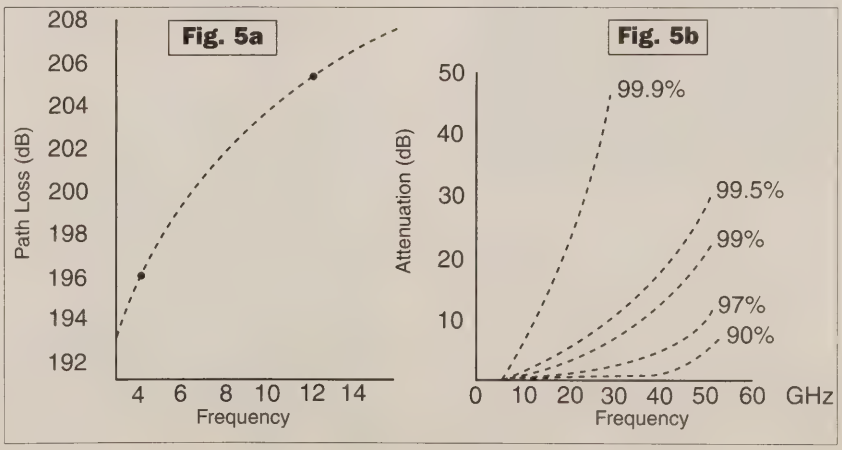
Whilst this might be agreeable for commercial operators, the same criteria could not be applied to a home receiving system, due to the high costs involved in providing the larger dish required. How this problem is overcome is by analysing the amount of time per year that heavy rainfall occurs, (usually relatively small), and by making calculations based on a "percentage availability" basis. Refer Fig. 5b.

If the user can accept that the system will produce desired signals for 98 or 99% of the time, and that during periods of heavy rainfall the received signal will be degraded, a far more cost effective system can be built.

A larger antenna has higher gain, so if cost is no object a large antenna can be employed. However a large antenna has a much narrower beamwidth than a small antenna, and this can make dish pointing much more difficult, especially at K band.

A formula for calculating the C/N is available, however, this still involves complicated calculations.

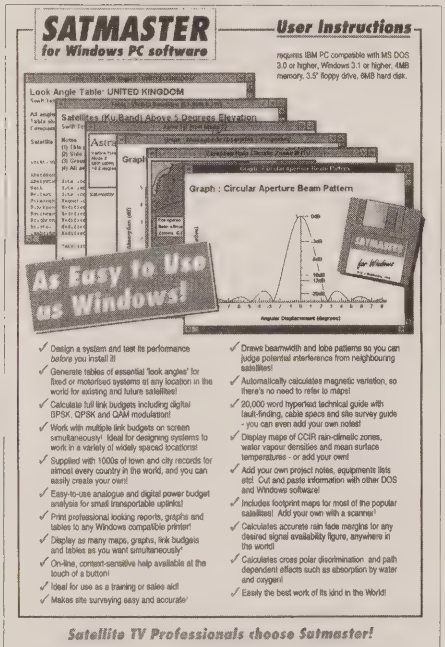
Fortunately, with the proliferation of the affordable personal computer, sophisticated software is now available to enable calculation



of analogue or digital signal downlink budgets. Such software is also capable of calculating rain fade margins, solar outages, performance margin for a given power level and dish size, etc.

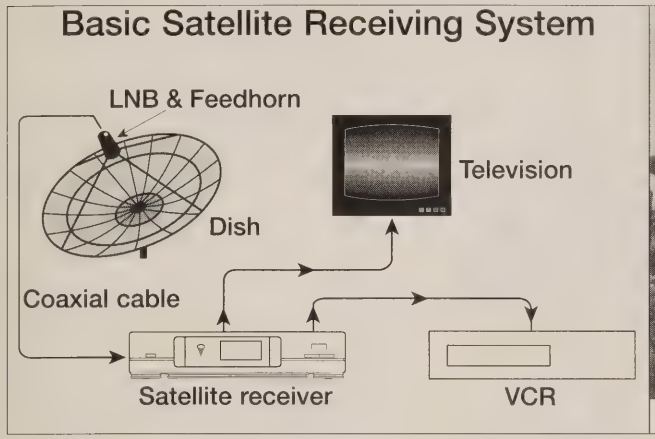
One such program is "Satmaster Pro", which sells for less than $200.

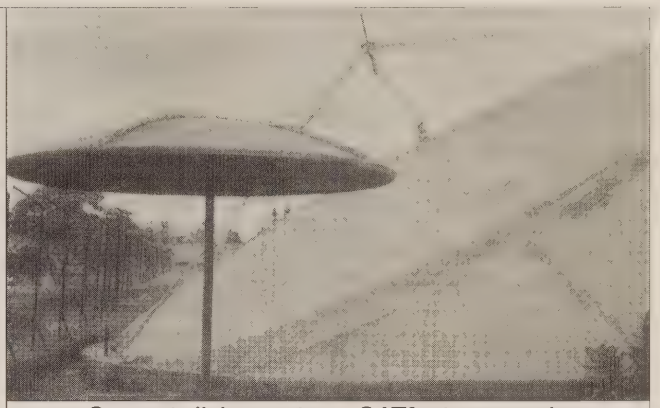
An example of the Link budget calculations provided by this program is shown at right.


SATMASTER
for Windows PC software
User Instructions
requires IBM PC compatible with MS DOS 3.0 or higher, Windows 3.1 or higher, 4MB memory, 3.5" floppy drive, 6MB hard disk.
Look Angle Table: UNITED KINGDOM
Satellites (Ku Band) Above 5 Degrees Elevation
Graph : Circular Aperture Beam Pattern
As Easy to Use as Windows!
✓ Design a system and test its performance before you install it!
✓ Generate tables of essential 'look angles' for fixed or motorised systems at any location in the world for existing and future satellites!
✓ Calculate full link budgets including digital BPSK, QPSK and QAM modulation!
✓ Work with multiple link budgets on screen simultaneously! Ideal for designing systems to work in a variety of widely spaced locations!
✓ Supplied with 1000s of town and city records for almost every country in the world, and you can easily create your own!
✓ Easy-to-use analogue and digital power budget analysis for small transportable uplinks!
✓ Print professional looking reports, graphs and tables to any Windows compatible printer!
✓ Display as many maps, graphs, link budgets and tables as you want simultaneously!
✓ On-line, context-sensitive help available at the touch of a button!
✓ Ideal for use as a training or sales aid!
✓ Makes site surveying easy and accurate!
✓ Draws beamwidth and lobe patterns so you can judge potential interference from neighbouring satellites!
✓ Automatically calculates magnetic variation, so there's no need to refer to maps!
✓ 20,000 word hypertext technical guide with fault-finding, cable specs and site survey guide - you can even add your own notes!
✓ Display maps of CCIR rain-climatic zones, water vapour densities and mean surface temperatures - or add your own!
✓ Add your own project notes, equipments lists etc! Cut and paste information with other DOS and Windows software!
✓ Includes footprint maps for most of the popular satellites! Add your own with a scanner!
✓ Calculates accurate rain fade margins for any desired signal availability figure, anywhere in the world!
✓ Calculates cross polar discrimination and path dependent effects such as absorption by water and oxygen!
✓ Easily the best work of its kind in the World!
Satellite TV Professionals choose Satmaster!

Courtesy: Swift Television

Downlink Analysis (1.6m Antenna)	
Produced using Satmaster (Sunday, May 19, 1996)	
Site name	Sydney
Satellite name	Optus B1
Summary of Input Parameters	
Site latitude	34S (degrees)
Site longitude	151.2E (degrees)
Magnetic variation	12.25E (degrees)
Site altitude	0.1 Kilometres
Satellite longitude	160E (degrees)
Spot beam polarisation cant	43.78 degrees
Channel/Transponder frequency	12.455 GHz
Antenna efficiency	75%
Antenna noise	30K
LNB noise figure	1.0 dB
LNB gain	60 dB
LNB load impedance	75 Ohms
Coupling loss (waveguides and polarisers)	0.2 dB
EIRP	44 dBW
RF/IF noise bandwidth	27 MHz
FM deviation (peak to peak)	17 MHz
Maximum video frequency	5 MHz
Pre-emphasis/De-emphasis	0.2 dB
Weighting factor	11.2 dB
Demodulator threshold	6 dB
Antenna aging, pointing & polarisation loss	0.2 dB
Signal availability (average year)	99%
CCIR rain climatic zone	F
Water vapour density	14 gm/cu. metre
Surface temperature	22 degrees C
Polarisation	Vertical
Satellite Look Angles	
Elevation angle	49.36 degrees
True azimuth angle	15.47 degrees
Azimuth compass bearing	3.22 degrees
Polarisation offset	-31.00 degrees
Modified Polar Mount Settings	
Polar axis angle	34.65 degrees
Polar elevation angle	55.35 degrees
Declination offset angle	4.87 degrees
Apex axis angle	39.52 degrees
Apex elevation angle	50.48 degrees
Clear Sky Result (no rain in downlink path)	
Path distance to satellite	37119.30 Km
Free space path loss	205.75 dB
Spreading loss	162.38 dB/sq. m
Atmosperic gaseous absorption	0.11 dB
Tropospheric scintillation fading	0.05 dB
Total atmospheric losses	0.15 dB
Effective area of antenna	1.78 dB sq. m
Antenna gain	45.15 dBi
Pre-detection noise bandwidth	74.31 dBHz
LNB noise temperature	75.09 K
System noise temperature	127.84 K
Power flux density (PFD)	-118.54 dBW/sq. m
Total carrier power	-116.95 dBW
Total system noise power	-133.22 dBW
Carrier power at LNB output	-57.15 dBW
Signal level at LNB output (75 Ohm)	
Nominal figure of merit, (G/T) nom	23.88 dB/K
Carrier to noise ratio (C/N)	16.27 dB
FM improvement (modulation gain)	19.71 dB
Signal to noise ratio (S/N)	49.18 dB
Picture quality	CCIR grade 4.8
Degraded Sky Result (99% of an average year)	
Signal availability (worst month)	97.15 percent
Attenuation due to precipitation	0.30 dB
Noise increase due to precipitation	0.54 dB
System noise temperature	144.71 K
Additional atmospheric absorption	0.02 dB
Downlink degradation (DND)	0.86 dB
Cross polar discrimination (XPD)	48.88 dB
Power flux density (PFD)	-118.86 dBW/sq. m
Total carrier power	-117.47 dBW
Total system noise power	-132.68 dBW
Carrier power at LNB output	-57.47 dBW
Signal level at LNB output (75 Ohm)	81.28 dBuV (21.28 dBmV)
Usable figure of merit (G/T) usable	23.14 dB/K
Carrier to noise ratio (C/N)	15.21 dB
FM improvement (modulation gain)	19.71 dB
Signal to noise ratio (S/N)	48.12 dB
Picture quality	CCIR grade 4.8




Cement dish *courtesy: SATfacts magazine*

A basic satellite receiving system comprises a dish, feed horn, LNB (Low Noise Block converter), receiver, television set and VCR or the combination of video monitor and audio amplifier. For reception of worldwide video standards, a multistandard video converter may also be necessary.

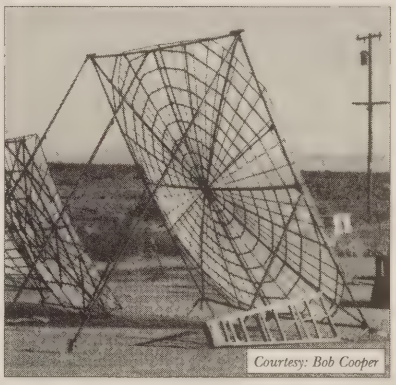
Television services designed to be received by small aperture domestic dishes are commonly called DBS or "direct broadcast services", and are confined to the K band. The relatively large C band dishes, sometimes seen in suburban backyards, and often 3-5 metres in diameter, are used to intercept television signals designed to be received by regional TV stations, hotels and other commercial organisations operating under copyright licensed conditions. The private practice of intercepting these signals is widespread in areas of poor, or non existant terrestrial broadcasts. Recently, there has been an increase in the number of foreign countries broadcasting FTA (Free To Air) to an international audience. Often these broadcasts are an extension of government funded shortwave radio services. Examples of this are NHK, DW (Germany), TV5 (France), TVe1 (Spain), RAI (Italy). Such broadcasts are intended to benefit expatriate citizens and potential tourists.

Dish Types

The dish, the most obvious component of a satellite system is normally parabolic in shape and made from steel, aluminium, or fibreglass sheeting impregnated with reflective coating. Some manufacturers use mesh or perforated sheet instead of solid sheeting to achieve some reduction in wind resistance. The dish must also be coated with some kind of weatherproofing material to prevent corrosion and pitting of the reflective surface.

The first type of dish specifically developed for TVRO use was the "spherical" type, developed by Oliver Swan in 1978. This antenna was suitable for fixed satellite installations with plenty of room! By placing several feedhorns at different places across the antenna, it was possible to receive more than one satellite. By moving the feedhorn rather than the reflector, several satellites could be received. This type of antenna was first used around 1979 in outback satellite systems, utilising Intelsat 4.

Small dishes (up to 2 metres in diameter) may be produced in 1 piece, either spun from aluminium, hot pressed from steel, or if fibreglass, made in a mold. There have been instances where large dishes have been built from other unorthodox materials. One such unique example is the 16 metre antenna, fabricated on site in Sri Lanka using cement, and aluminium foil!


Courtesy: Bob Cooper

One piece construction is generally considered impractical for larger sized dishes which are often made up of a number of identical "petals". In addition, larger

dishes have higher wind resistance, requiring stronger construction and mounting techniques than their smaller counterparts.

In practice, most dishes over the diameter of 2.3m are made from aluminium expanded mesh panels, which are then bolted together to form the complete parabolic reflector. The advantages of this construction technique are lower wind resistance, and ease of shipping.

However, mesh panels are somewhat fragile, and can be damaged by hail, resulting in deviation from the true parabolic surface, and subsequent gain reduction. Large antennas for commercial installations where a reduction in performance cannot be tolerated normally use solid dishes, despite mounting and shipping difficulties.

Gain

The most important parameter of the dish is its gain and this is dependant on the area and accuracy of the parabolic surface. Any imperfections or deviations exceeding 25 percent of a wave length, or more from a perfectly parabolic surface can result in a significant drop in efficiency.

The larger the dish, the greater the gain, provided the surface closely follows the true parabolic shape.

Dish size versus Gain		
SIZE	K BAND	C BAND
1.6M	44dBi	34dBi
1.8M	45dBi	35dBi
2.3M	47dBi	38dBi
3.0M	49dBi	41dBi
3.7M	50dBi	42dBi

The gain of a dish is generally expressed as :

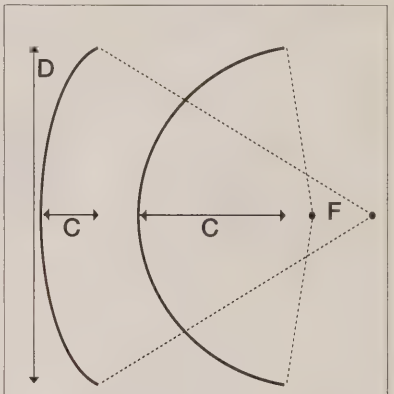
$$GAIN = \mu(D^2/L)$$

Where D equals the diameter of the dish in metres, lamda equals the wave length of operation in metres, and μ equals the efficiency (typically 60 to 70 %). Typically, a solid dish has higher efficiency than one made from mesh panels. At K band, efficiency of mesh dishes can drop to 35%. The purpose of the dish is two-fold, to collect the maximum available signal, and focus this signal into the feedhorn.

It is important to appreciate different dish designs. A parabolic dish can have either a shallow to a deep parabolic curve. This in turn will determine the focal point, which is important for correct placement of the feedhorn.

Every dish has a design "focal length to diameter" or F/D ratio. This simply means that the amount of curvature built into the dish establishes a relationship between the diameter and the distance from the back of the dish to the focal point. This ratio can easily be calculated by measuring the diameter across the front of the dish and the depth, or distance from the back of the dish to the point of intersection across the front. In practice this can easily be done by using a piece of string stretched across the front of the dish and a rigid tape measure. The formula for calculating the focal point is shown below.

$$\frac{F = D^2}{16C}$$



Shallow dish/ Deep dish

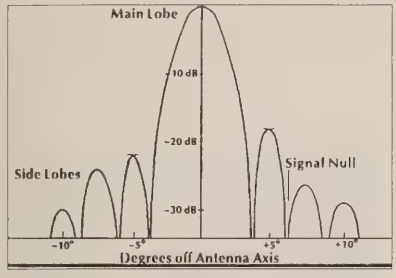
Where C equals the depth, D equals the diameter and F equals the focal point. One confusing aspect of this is that a dish having an F/D ratio of 0.5 is actually shallower than one having a F/D ratio of 0.25, although the magnitude of the ratio might seem to indicate otherwise.

Noise Temperature

Dish noise temperature is also an important parameter, and refers to the amount of noise detected by the antenna from the surrounding environment. Factors influencing dish noise temperature include dish diameter, dish elevation and dish sidelobe performance.

The sidelobe performance of any dish, is most simply described as the ability of the antenna to reject signals from anything other than the intended single point source. Sidelobe performance is also related to antenna beamwidth. If absolutely all the incoming signal was received by the main directional beam or "lobe" of the antenna, the efficiency would be very high, as all other sources of noise or signals would not be seen by the antenna. In practice, due to

reflector shape and design, some efficiency is lost due to the antenna sidelobe response. Noise is also admitted into the antenna system through sidelobe responses.



In general a larger dish has a lower noise temperature than a smaller dish, because of the narrower beamwidth. Also, earth noise plays a part in dish noise temperature at lower elevations. The earth has a higher noise temperature than free space,(290 degrees Kelvin versus 5 or 6 degrees Kelvin for free space) and consequently some earth noise enters the dish via sidelobes.

For dishes "looking" at satellites having a low angle of elevation, a dish having a deep focal point, may provide a better carrier to noise ratio at the output of the LNB, as the feed system is shielded from earth noise to some degree, due to the shorter focal length.

The resultant G/T ratio, or "figure of merit" of a dish, feedhorn and LNB combination is calculated, in simple terms, by dividing the gain of the antenna, by the noise figure of the system. That noise figure can be simplified as the sum of the dish noise temperature and the LNB. A 20 degree K LNB contributes 20 degrees to the system noise figure.

Home satellite systems generally strive for a figure of merit of 15 to 20dB/degree Kelvin, whilst commercial installations should achieve up to 30dB/degree Kelvin. In terms of extra performance margin, a home satellite system should be built to have at least 1dB of extra C/N margin, whilst a commercial system should have an extra 3dB of inbuilt performance margin.

Offset Dishes

Offset dishes were developed primarily for use in high latitude countries, where the effect of water, snow, or ice pooling on the reflector surface would degrade performance of a prime focus dish.

Because the offset reflector is actually only a section of a larger prime focus reflector, the offset angle means that the actual angle of the reflector with respect to the horizontal plane is much higher than that of a prime focus reflector, ensuring that rain, snow and ice easily fall off the surface. This also means that the offset angle must be taken into account when pointing an offset dish. If, for example, the calculated angle of elevation for a prime focus dish is 50 degrees, then the actual angle of elevation of an offset reflector is that angle of elevation, minus the offset angle.

In addition, most offset antennas are elliptical, having a longer vertical axis than horizontal axis. This reduces the antenna beamwidth, an important parameter in countries served by many adjacent satellites.

In Australia, we generally avoid such problems, due to our climate. However the compact size of offset dishes has made them popular with Pay TV providers, despite their mechanical instability for sizes over 90cm. Offset dishes have very good sidelobe performance and no aperture blockage, unlike the prime focus dish. Never the less, the prime focus dish is much easier to align and point, and has superior cross polarisation performance.0 Figure 7 shows the relationship between prime focus and offset reflectors.

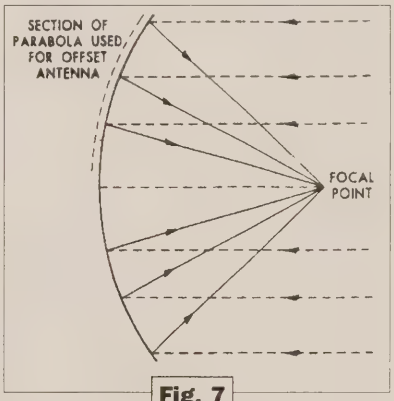
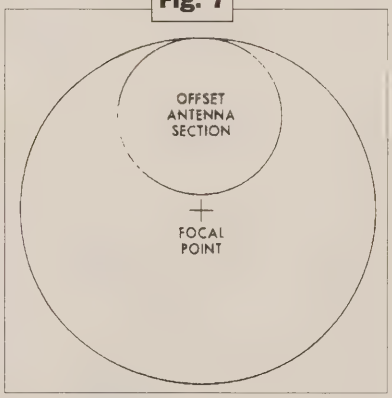


Fig. 7

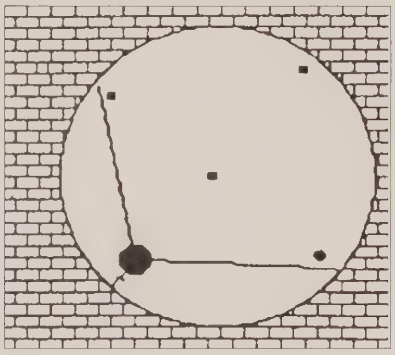


Flat Antennas

A few manufacturers around the world are making flat antennas. The main advantge of a flat antenna is low profile and wind loading. This can be especially useful when a dish must be installed on a high rise building, or

where architectural or planning regulations prohibit conventional parabolic dishes. Flat antennas are also less susceptible to terrestrial interference, and have a broader alignment tolerance than their parabolic counterparts. Flat antennas can be mounted on either horizontal or vertical surfaces.

One type of flat antenna is known as a "zone plate antenna". When mounted on a vertical wall, the zone plate antenna can be skewed to point at the satellite.



The disadvantge of the zone plate antenna, is reduced efficiency when compared to a parabolic reflector. Whilst this may be of no consequence when using the antenna for K band, where larger antenna dimensions can be tolerated, flat antennas for C band typically have an efficiency of 50-55%, requiring a larger aperture flat antenna for equivalent performance.

The internal construction of the reflector consists of a single piece, stepped, elliptical reflector. The base of the reflector is either moulded from epoxy resin, or machined from a block of similar material. After machining or moulding, the reflector is sprayed with a conductive material to ensure good reflection properties at satellite frequencies.

Typical F/D ratio of a flat antenna is 0.7, and offset feedhorns are typically used to illuminate the elliptical reflector "potted" in weatherproof epoxy resin.

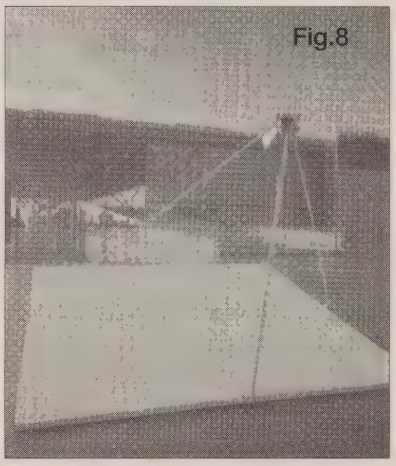


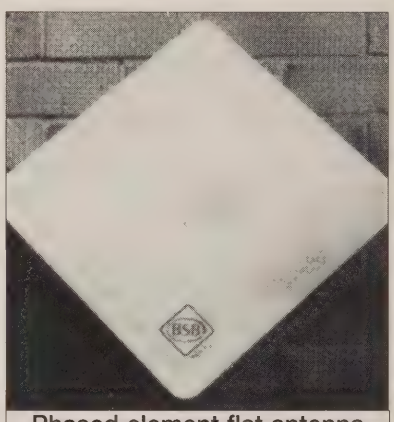
Figure 8 shows a C band zone plate antenna.

Another type of flat antenna is the "phased element" type.

The flat plate antenna is a phased array of 256 dipole antenna elements arranged in a square, so that they are all in phase across the surface of the array. This way, the signals received by each dipole antenna are combined and fed to a waveguide.

A commercial flat plate antenna, developed in the UK for reception of BSB (British Satellite Broadcasting) is commonly sold in the UK under the tradename "Squarial". Because the beamwidth of this type of antenna is commonly 4°-5°, they are normally wall mounted offset 45° to the vertical axis.

This way the high side lobes are aimed in the opposite direction to the geostationary arc. Because the gain of a flat plate antenna is uniform across the surface (unlike parabolic antennas which normally employ up to 10dB "edge taper"), they are more efficient (and costly) than a parabolic dish of equivalent size.



Phased element flat antenna

Feedhorns

The primary function of the feedhorn is to gather the reflected energy from the dish and direct it to the LNB. At the same time, it should reject outside "noise" caused primarily by random microwave signals and ground noise.

It is important that the feed horn illuminates the entire dish, not just part of it, to achieve maximum efficiency. Feedhorns are manufactured to suit dishes having a particular F/D ratio, so the choice of feedhorn is important.

There are several different feedhorn arrangements. The most simple and widely used is the "prime focus" feed where the feedhorn is placed at the focal point of the dish. Whilst this is a simple arrangement,

alignment is critical.

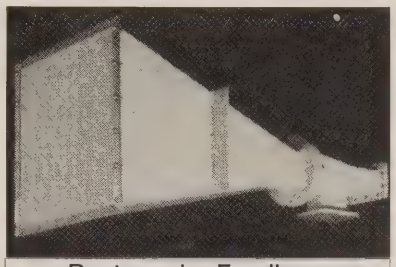
Another type of feedhorn arrangement is the "cassegrain" feed. This system uses two reflectors: the dish itself and a small subreflector at the focal point. This reflector has the shape of a hyperbole and reflects the signals through a hole in the centre of the dish to the feed horn and LNB. This system has a higher gain/noise ratio and is superior in performance to the prime focus system, but only on large dishes where the dish size compensates for aperture blockage caused by the subreflector.

Focal Point

The focal point of a dish is determined by its curve and thus the shape of the dish establishes the feed parameters as well as the focal point for the feed horn.

Since deep dishes have a relatively close focal point, feed horns for deep dishes must have a broad beamwidth. Shallow dishes have the focal point further away and therefore a narrower beamwidth is required. When a dish is fully illuminated its efficiency is at maximum. However, at the same time, ground noise is also at a maximum. The microwave energy from a satellite radiates in two modes, the "E" and "H", electrical and magnetic fields.

Due to the different electrical and magnetic characteristics of these two fields, a feedhorn must have special designs to allow it to "see" the dish equally in both fields. For many years the classic rectangular feed has been used in an attempt to



Rectangular Feedhorn

equalise the differences between "E" and "H" fields.

An improved solution for this mismatched problem was developed several years ago through the understanding of the electrical and magnetic properties and their interaction within the feedhorn. The solution is a "scalar" feedhorn, a circular feedhorn design, with a series of chokes or rings that equalise the two planes so that the microwave response is nearly flat from one plane to the other. The "E" field tends to spill over the walls of the throat of a feedhorn to follow the outside of the feed.

A method is needed to reduce this fringing without effecting the main energy within the feedhorn. This is accomplished by using quarter wave chokes set as concentric rings around the feedhorn opening. These concentric rings are a quarter wave length in height, allowing an impedance match, ensuring the rings have maximum cancellation effect. Once the pattern of the "E" and "H"

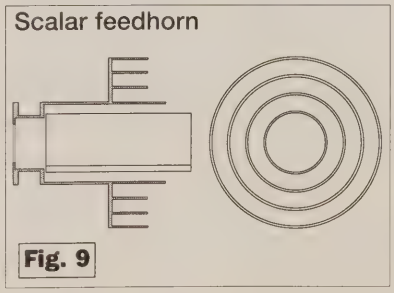


Fig. 9

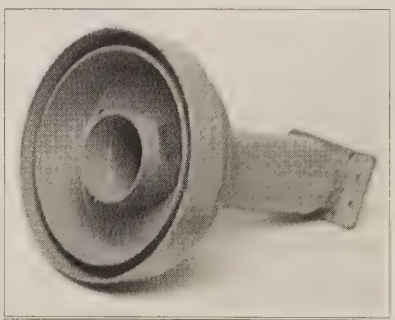
fields is equalised, the primary function of the feedhorn is to channel the energy into the LNB. Fig 9 shows scalar rings, fitted to a feedhorn.

The waveguide must have precise dimensions to keep VSWR (Voltage Standing Wave Ratio) as low as possible. Sometimes, small screws or projections extending into the waveguide at various points are installed by the manufacturer to further lower the VSWR or to correct for a shortened waveguide. High quality feed horns have a VSWR of 1.3 : 1 or lower.

Another type of feedhorn, giving superior results to the "Scalar" feed, is the "Moded", or more specifically, the "Dual Hybrid Mode" feedhorn. The design of this kind of feedhorn comes from an adaptation of a feedhorn developed at the Jet Propulsion Laboratory for use on the Pioneer series of spacecraft.

US feedhorn maker ADL were the first to combine the moded feed design with a high efficiency polariser, and to produce a feedhorn suitable for C band home satellite TV reception.

This type of feedhorn can improve the system efficiency by several dB.



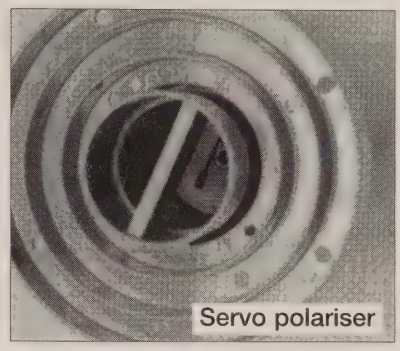
Dual hybrid mode Feedhorn

Polarisers

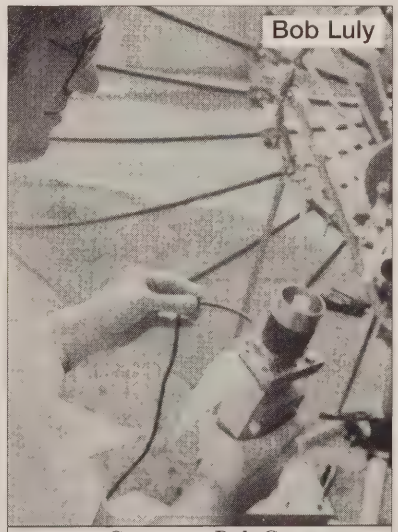
The feedhorn can also incorporate a polariser, a device used to select correct reception polarity. To ensure good frequency reuse, most satellite adjacent transponders are fixed alternately between vertical and horizontal polarisation.

In order to receive vertically polarised signals, the LNB/feed horn arrangement must be rotated to compensate for ionospheric cross-polarisation which may occur during the downlink. Because the LNB dipole probe is fixed when the LNB is manufactured, it cannot be moved to allow reception of different polarity signals. Nor is it convenient for the user to have to rotate the LNB every time a transponder having a different polarity is selected. To counter these problems various mechanical rotation devices have been used over the years with varying degrees of success.

The most commonly used system employs a digital proportional servo motor to rotate a probe mounted inside the waveguide. This type of motor is sufficiently agile to change position quickly, can provide sufficient torque, and requires minimal DC current to maintain the probe position. This probe is mutually coupled to the LNB dipole antenna. This arrangement allows the remote selection of signal polarity from the satellite receiver. Unfortunately, this type of feedhorn has significant loss, and can only be used in areas of high signal strength.



One "non-moving parts" solution is to use a magnetic polariser. This system uses the principle of Faraday rotation where an axial magnetic field is applied to a waveguide containing ferrite material. A current carrying coil is wound around a ferrite rod and the resulting magnetic field changes the polarisation of the incoming signal. The amount of rotation is proportional to the amount of current flowing through the coil. The advantage of this system is the low insertion loss, typically 0.15dB.



Courtesy: Bob Cooper

This type of polariser is mainly used for K band reception, where the higher insertion loss of a mechanically rotated probe cannot be tolerated.

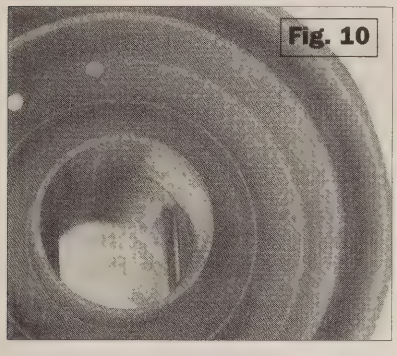
In the early 1980s a C band version of this type of polariser was displayed at the SBCA satellite show by Bob Luly, who is generally credited with the development of this type of polariser.

For C band applications, a mechanical polariser is generally used, where selection of vertical and horizontal signals is required. A magnetic polariser for C band use is not commercially available, probably due to the high cost.

Some satellites use linear polarisation. Normally this means that adjacent transponders are, alternately vertical or horizontal in polarity. This is the case with Panamsat's PAS 2 and the Indonesian "Palapa" satellites. However, other C band satellites viewable in the Pacific area utilise circular polarisation, Intelsat and the Russian "Gorizont" satellites using a combination of left hand, and right hand circular polarisation (LHCP & RHCP). In the situation where the user desires to remotely select either polarity, a mechanical polariser is used, and a dielectric plate is inserted in the throat of the feedhorn to convert linear to circular polarisation. This method introduces considerable loss into the feed system.

A far more efficient method of converting signals from circular to linear polarisation (over the introduction of a polarising element inside the waveguide) is to introduce polarising structures into the waveguide. Manufacturers such as ADL produce a "dual hybrid mode" feedhorn, offering a 2dB improvement in efficiency

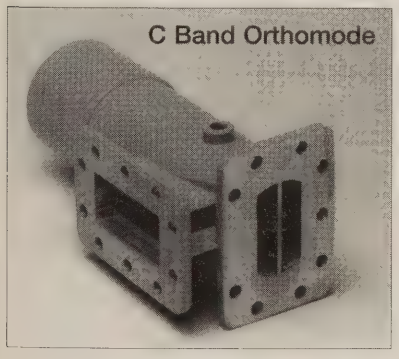
over the standard scalar feed with dielectric plate. Fig 10 shows structures inside the waveguide that cause circular to linear polarisation conversion of microwave signals.



A further improvement involves the use of a rotating waveguide. The main advantage this system has over other types, is that it allows the entire LNB and waveguide to be rotated, to compensate for polar axis "roll", encountered when using a polar or horizon to horizon mount. This feedhorn is also manufactured in "dual band" configuration.

Orthomode Feedhorn

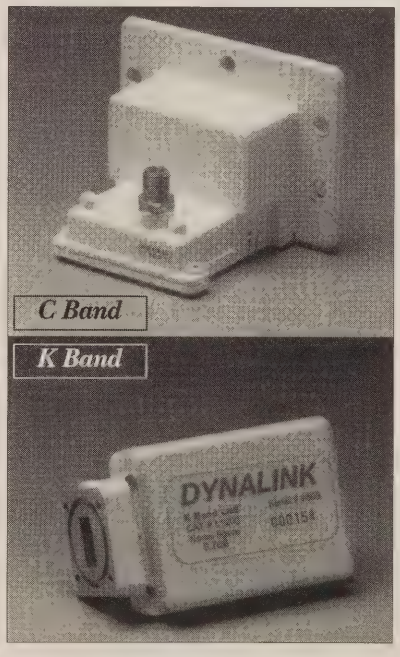
This type of feedhorn is used when two signals having different polarisation need to be received simultaneously, by feeding two LNBs.



This type of feedhorn is often used in SMATV installations where all available channels must operate simultaneously. When used with a suitable polarity switch, multiple receivers can be operated from the one dish, each with independant polarity control.

LNBs - Single Polarity

The LNB is a critical component of a satellite system. It is this item which largely sets the carrier to noise ratio of the complete system. An LNB is, in simplistic terms, a wideband mixer. The incoming satellite signal is mixed with a stable microwave oscillator to produce a 500MHz wide block of output, or IF frequencies, most commonly in the 950-1450MHz region. LNBs operating in the K band use a local oscillator frequency of 11.3GHz, whilst C band units use an LO frequency of 5.15GHz.



Most LNBs are produced to receive signals of a single polarisation. The waveguide "port" which is bolted directly to the feedhorn has specific dimensions. For our part of the world, where K band ranges from 12.25GHz to 12.75GHz, the single polarisation waveguide is called WR 75. For C band, the waveguide is known as WR 225.

To calculate the IF frequency (to which the receiver must be tuned) for K band, subtract the LO frequency of 11.3GHz (11300MHz) from the incoming frequency.

For C band, the incoming frequency must be subtracted from the local oscillator frequency of 5.150GHz, to give the IF frequency to which the receiver must be tuned.

The incoming satellite signal is amplified prior to mixing with the local oscillator, and it is the noise figure of this first amplifier stage, which largely sets the LNB noise figure. The lower the noise figure of the LNB, the better the ability to receive weak signals.

As a rough rule of thumb, approximately 0.6 dB of equivalent system gain is added for every 20°K drop in LNB noise temperature.

The table (following page) shows the relationship between noise temperature in degrees K and dB.

Convention dictates that the noise figure of a C band LNB is expressed in degrees Kelvin, whilst that of K band LNBs is expressed in dB.

LNBs having noise figures of 0.7dB (50 degrees Kelvin) are now available for K band, whilst 0.3dB (20 degrees Kelvin) is readily achieved at C

NOISE TEMPERATURE TO NOISE FIGURE CONVERSION CHART	
NOISE TEMPERATURE	NOISE FIGURE(dB)
010	0.148
015	0.220
020	0.291
025	0.360
030	0.429
035	0.496
040	0.563
045	0.628
050	0.693
055	0.757
060	0.819
065	0.881
070	0.942
075	1.002
080	1.061
085	1.120
090	1.177
095	1.234
100	1.291
105	1.346
110	1.401
115	1.455
120	1.508
125	1.561
130	1.613
135	1.665
140	1.716
145	1.766
150	1.816
155	1.865
160	1.913
165	1.962
170	2.009
175	2.056
180	2.103
185	2.149
190	2.194
195	2.239
200	2.284
205	2.328
210	2.372
215	2.415
220	2.458
225	2.501
230	2.543
235	2.584
240	2.626
245	2.666
250	2.707

band. Enthusiasts should strive to obtain the best possible noise figure LNB. However, it is important to understand that no visible difference may be seen between a system using a 20 degree LNB and one using a 15 degree LNB.

What is important, is the improvement in performance headroom, which helps compensate for reduced satellite power due to TWT ageing, and atmospheric conditions affecting path loss.

Another important parameter of LNB performance is local oscillator drift. For TV work, LNB LO drift of +/- 2.5MHz or so is acceptable, as the video transponder bandwidth is typically either 18 or 30MHz, and the receiver AFC can track LNB drift.

Digital MPEG receivers require a higher degree of stability, less than 800KHz total drift is preferred.

However, for NBFM (narrow band FM) SCPC radio reception, where the channel bandwidth is only 30 kilohertz, such an amount of drift would prevent repeatable reception on a day to day basis, as the LNB LO frequency shifts with the change in ambient temperature, and hence the IF frequency would have also moved. This problem has been overcome using a PLL LNB. This LNB has a maximum drift of less than 50KHz from -20 degrees C to + 60 degrees C, quite a dramatic improvement.

PLL LNB performance specifications

R.F FREQUENCY RANGE	: 12.25–12.75 GHz
DRO LO FREQUENCY	: 11.30 GHz
LO FEQ. STABILITY	: +/- 30KHz
OUTPUT FREQUENCY	: 950 – 1450 MHz
GAIN	: 55 dB (TYP.)
GAIN FLATNESS	:6 dB P–P
GAIN RIPPLE	: ± 1 dB/ 36 MHz
OUTPUT POWER	: 0 dB @ 1 dB
OUTPUT IMPEDANCE	: 75 Ω
OUTPUT VSWR	: 2.5:1 (MAX.)
NOISE FIGURE	: 1.0 db
DC SUPPLY	: 15V–24V/200mA
INPUT CONNECTOR	: WR - 75
OUTPUT CONNECTOR	: TYPE F
IMR	: 55 dB (MIN.)
LO LEAKAGE AT INPUT	: -60 dBm (MAX.)
OUTPUT SPURIOUS	: -70 dBm (MAX.)

With the widespread conversion of many SCPC links to digital format, which improves audio dynamic range, and reduces uplink costs, the demand for SCPC equipment is now limited to commercial and aviation applications.

Wideband LNBs

There is also an increasing number or manufacturers producing "wideband" LNBs. For K band this means covering from 10.5GHz to 12.75GHz. Normally two local oscillators are used, one at 10.75GHz and the other at 11.3GHz. Switching between local oscillators is achieved through the 14/18V switching facility, common on almost all modern satellite receivers.

Wideband coverage of C band is presently limited to Palapa C, Apstar and Thaicom satellites which offer extended C band coverage from 3.4GHz to 4.2GHz. LNBs intended for use over this extended band must be specially produced, so that the frequency response rolls off below 3.4GHz.

Integrated LNB and Feedhorn

Further developments in both C and K band feedhorn efficiency have been made by integrating the LNB, feedhorn and polariser in the one package, called the dual polarity LNBF.

LNBF

This is done by fitting the LNB with two RF stages, each with a separate dipole probe, one dedicated to horizontal polarity reception, the other dedicated to vertical signal reception. These probes are switched by changing the DC

bias on the coaxial feedline. This arrangement eliminates the 0.2dB or so insertion loss of the magnetic polariser, dramatically improving picture quality.

Latest Developments

Promoted as being a "one cable solution" the latest C band dual polarity LNB allows simultaneous reception of horizontal and vertically polarised signals by utilising 2 probes mounted 90 degrees apart. Each probe feeds a separate amplifier, mixer and local oscillator chain, providing two separate 500MHz wide "blocks" of output signals, fed down the one cable.

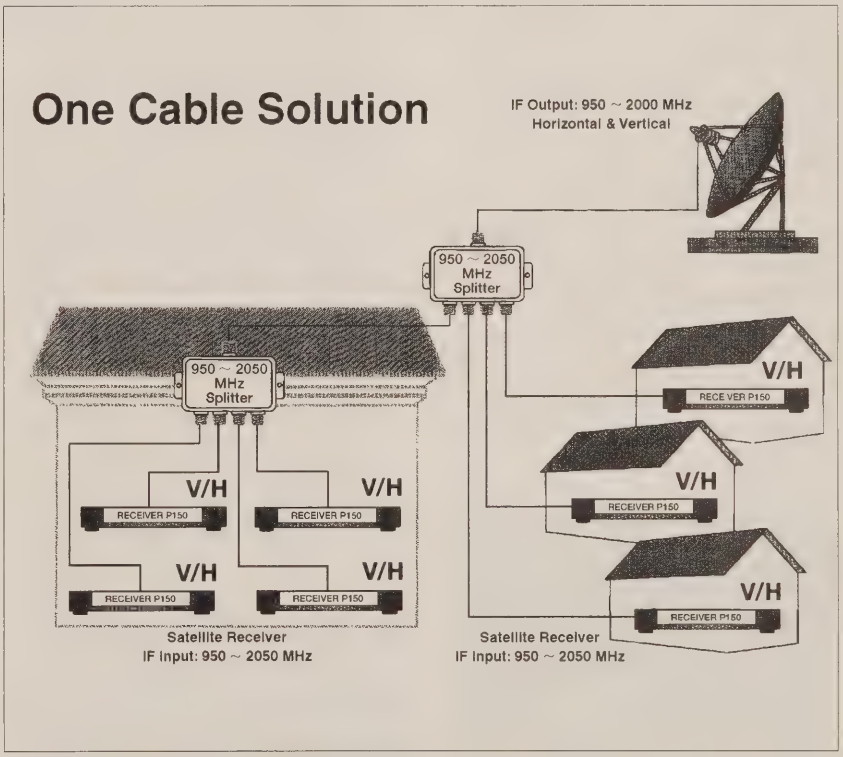
This new type of LNB converts all incoming vertically polarised signals to an IF block of frequencies from 950-1450 MHz, and simultaneously all horizontally polarised satellite signals are converted to another block of IF frequencies from 1500 -2000 MHz.

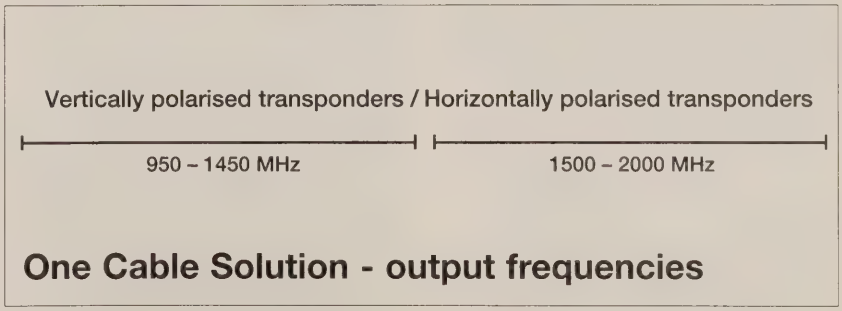
As long as the receiver used is rated to 2000 MHz, and provided the IF cable is also so rated, a simple IF splitter is all that is needed to separate vertical and horizontal signals at the receiver end of the cable. This special type of LNB has two internal local oscillators, one running at 5.15 GHz, the other at 5.7 GHz.*

Although there is a slight performance trade-off when using the "one cable solution", the ability to easily distribute multiple polarity signals without the complication of using a "multi-switch" is especially beneficial where reception of digital and analogue signals of both polarities is required. This approach ensures the LNB is always operated at the correct voltrage (18V). This type of LNB can also be used with the appropriate feedhorn to simultaneously receive LHCP and RHCP signals.

As this type of LNB has two internal local oscillators, one at 5150MHz, the other at 5700MHz, IF frequencies are calculated by subtracting the input (downlink) frequency from either 5150MHz or 5700MHz, depending upon which LNB probe is utilised.

*Some manufacturers use slightly different frequencies.





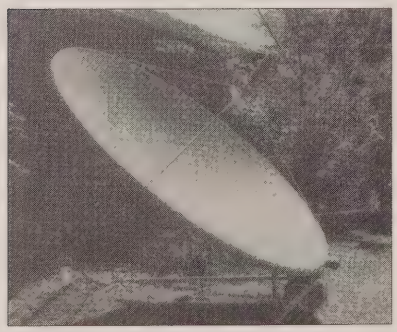
One Cable Solution - output frequencies

Dish Mounts

Regardless of the type of dish used for satellite reception, there are a number of different mechanical mounts that can be used to secure the reflector.

Ground Mount

The simplest type of mount is the ground mount, which is designed for fixed, single satellite reception. This mount comprises a triangular base frame, which sits horizontally on the ground (or any other flat surface). The reflector is fitted with a rim assembly, which has two pivot points at the front edge of the reflector rim, which form a support hinge with the base frame. A telescopic elevation arm, made from two sections of concentric pipe, forms the third support point, from the rear of the base frame to the reflector rim. This elevation arm is fitted with a friction screw, allowing the length of the arm to be set, corresponding to any value of elevation.



AZ/EL Mount

This mount is designed to allow the dish to be mounted on a vertical post or pole. Elevation can be varied, normally by adjusting the effective length of a piece of threaded steel rod. Azimuth adjustment is made by simply rotating the mount on the pole. For Az/El mounted dishes, the supporting pole is normally cemented into the ground. A good general rule of thumb is to bury as much of the pole below the ground as that length above the ground. The length of pole above the ground should be 100mm or so more than half the diameter of the dish.

This way, when the dish is tilted down to an elevation of zero degrees, the lower rim will not touch the ground. eg for a 3m dish, the pole length above the ground should be 1.5m plus 100mm = 1.6m.

A recent development is the motorised Az/El mount. This involves fixing the dish to a pole mounted on a bearing, which allows desired changes in azimuth to be made using a standard actuator. The advantage of this configuration is that no feedhorn correction for the polar axis changes is required as the dish azimuth is changed, as the dish moves in a straight line, rather than following the geostationary arc. However, an additional actuator is required for elevation adjustment, as no declination adjustment is available.

Polar Mount

A polar mount enables an antenna to track the geostationary arc using a single motor drive in the azimuth axis. The primary difference between a polar mount and an Az/El mount is the angle of azimuth axis. This is called the polar elevation angle. The angle of elevation of a polar mount varies with changes in dish azimuth. As the azimuth changes, the dish "rolls" around the axis of the mount, changing the angle of elevation.

Figure 15 shows the construction of a polar mount.

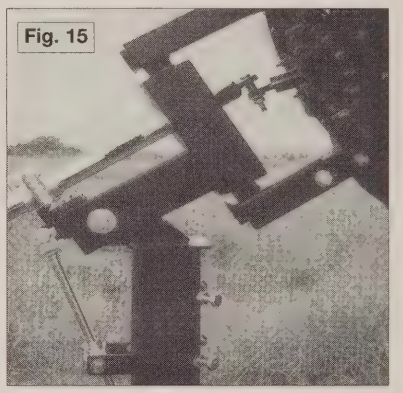


Fig. 15

For the dish to track the geostationary arc correctly, it is necessary to make a few simple adjustments. The mount must be aligned so that the point of highest elevation occurs at true north, the angle of elevation for the sight must be set, and the declination must be also be set to a pre -calculated value determined by the site latitude.

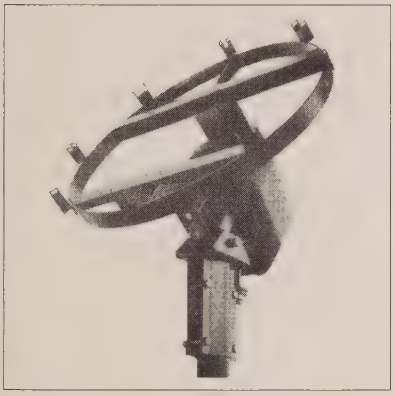
Horizon to Horizon Mounts

Horizon to horizon mounts are used when a dish must be driven significantly past the centre of gravity. In Australia, such a mount would be used when a TVRO system is required to receive satellites on both the far western horizon, and also the eastern horizon.

In Western Australia, it is possible to receive satellites from 60 to 180 degrees east longitude. Even along the east coast, satellites can be viewed from 80 to 180 degrees east longitude. Using dish pointing software, the calculated range

of azimuth adjustment is from 272 to 035 degrees magnetic, ie a 125 degree span. If reliable dish control is required across this azimuth range, a horizon to horizon mount should be used.

A horizon to horizon mount comprises a 36 volt reversible DC motor and a reduction gearbox, directly driving a series of toothed gears. These gears are immensely strong, and due to the reduction gearbox, the drive train is capable of very high torque. In addition, most "H/H" mounts use five reed sensors for more accurate positioning, compared to the single reed used on actuators.



For reception of satellites in inclined orbits (ie Gorizont and Intelsat) a second actuator, used to control dish elevation variations above and below the "nominal" elevation of a satellite in the geostationary arc, must be used. This applies equally to polar and horizon to horizon mounts. A heavy duty actuator should always be used for this purpose. Whilst the amount of travel required may only be a matter of 10 cm or so, the load bearing capability of the actuator is most important.

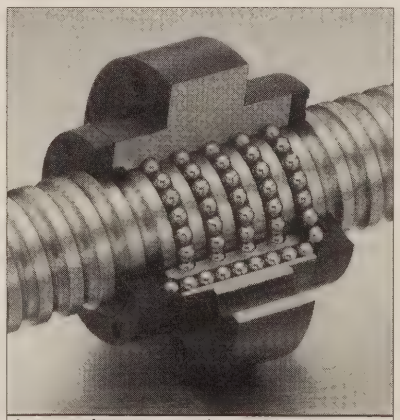
Dishes used to receive inclined orbit satellites must also be well balanced, often requiring the addition of a counter-weight.

Dish Accessories-Actuators

An actuator, or "linear actuator" as they are sometimes called, is a motorised drive unit, designed to move the dish in one axis. Mechanically, a 36 volt reversible DC motor is driven through a reduction gearbox, to drive an Acme or ball screw which either extends or retracts a telescoping tube located inside a fixed external tube.

There are two mounting points on an actuator; an adjustable collar which can be slid to any position on the external tube, and a swivel eye, located at the end of the internal tube. This style of actuator is called and "acme screw" type. Actuators are available in standard sizes: 6, 8, 12, 18, 24, 36 and 54 inches. The length of the extension available, is generally one inch less than the nominal size.

A superior type with far less internal friction loading is called a "ball screw" type. Due to the additional cost of this type of unit, it is seldom used in domestic installations.



Internal construction of ball screw

In addition to the DC motor and gearbox, all actuators have some kind of feedback mechanism, to allow remote control. Most actuators used today utilise a rotating magnet and reed switch as the feedback elements. For every rotation of the magnet, the reed switch operates. When fed with a 5 volt supply, the output of the reed switch appears as a series of 5 volt pulses. These pulses can be counted and memorised by the appropriate remote control drive unit.

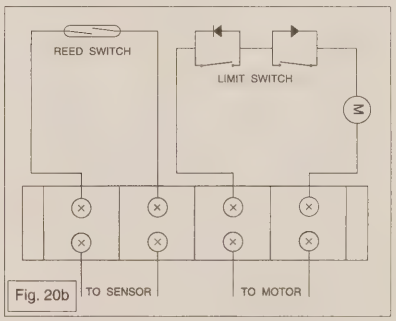


Fig. 20b

Past actuator designs have used potentiometer or optical sensors. These two feedback methods are now considered obsolete. Care should be taken to select actuators using a sensor system compatible with available dish controllers.

In addition to controller software limits which prevent an actuator from being driven too far (into a tree or the garage!!), most modern actuators have inbuilt limit switches. These switches comprise a microswitch, through which the DC voltage to the motor flows. The microswitch is operated by an adjustable cam, driven by the motor gearbox, which ensures the switch operates (interrupting the DC voltage), when a mechanical limit is approached. A reverse polarity

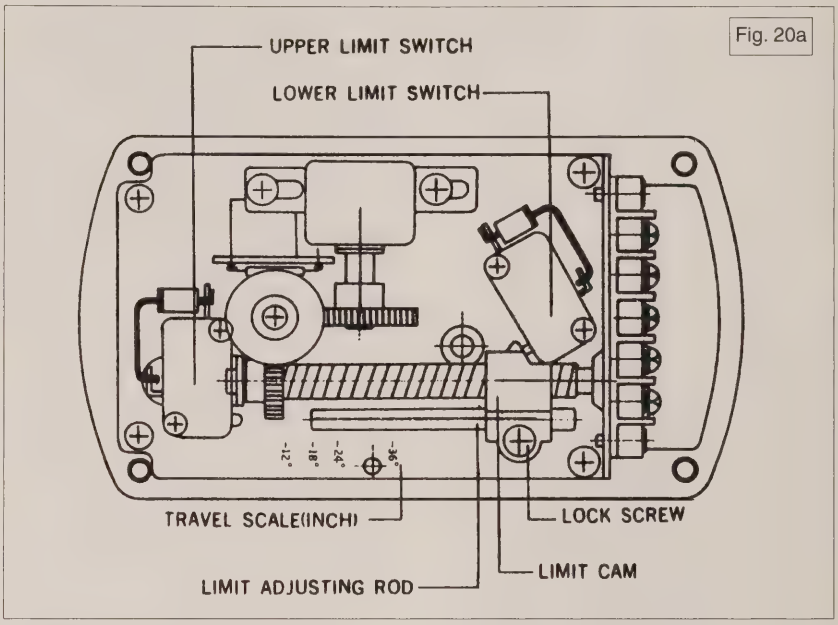
diode ensures the motor can always be driven in the opposite direction, away from the limit.

Fig. 20 shows both electrical (a - previous page) and mechanical (b) layout of a typical actuator.

The microswitch cam can be adjusted to provide any desired limit. Normally there are two microswitches, one each to set the minimum and maximum actuator travel. The minimum travel switch is normally set at the factory. It is important that limit switches are set prior to commissioning of the satellite system.

The limiting factor of dish actuators is the amount of available travel. Once a dish is driven by an actuator past the centre of gravity, an enormous amount of torque is required to move the dish.

Actuators do not have this capability, and the use of an actuator in this kind of situation, normally results in a bent outer tube. The



appropriate mechanism for moving a dish through a large azimuth range, is, as the name suggests the "horizon to horizon" drive.

Recently, in an attempt to reduce actuator noise, several manufacturers have introduced a drive system utilising a toothed drivebelt instead of direct gears, between motor and gearbox.

The results of this development are quite astonishing, and the use of this type of actuator, particularly when used in conjunction with a solid dish, can result in far lower actuator noise levels than has previously been possible.

Actuator Controllers

All actuators must be driven by a controller, which in simple terms is a 36V DC power supply with polarity reversal capability and a microprocessor controlled counter with memory. The controller has the ability to drive an actuator motor whilst counting feedback pulses from the actuator reed and rotating magnet assembly.

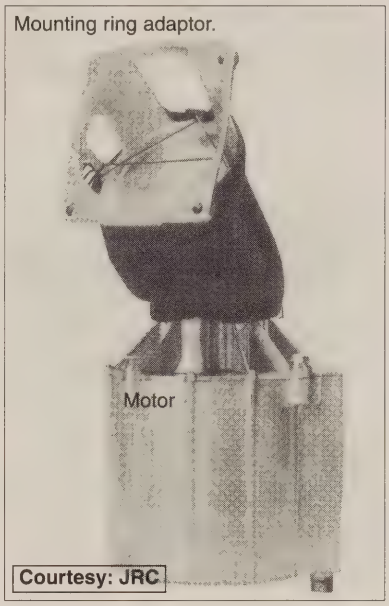
By storing the number of pulses in memory, a controller can be used to drive a dish motor to a memorised position corresponding to the correct azimuth for a satellite location. All modern positioners utilise infra-red remote control.

Robot Positioner

A recent development in antenna positioners is the "Robot Positioner", made in Japan. This system comprises two items: the indoor control unit, and the dual axis positioner module, mounted between parabolic reflector and mounting post. The interconnecting cable uses 18 conductors, which carry motor voltage and sensor feedback voltages.

A sophisticated microprocessor controller ensures azimuth accuracy of 0.01 degrees per pulse, and elevation accuracy of 0.0025 degrees per pulse, ensuring very accurate dish pointing. The microprocessor calculates the azimuth and elevation of every available satellite, based on the latitude and longitude of the dish site.

The system also has an "auto" fine tune feature, where the satellite signal is peaked using AGC voltage from the satellite receiver, if the satellite does not appear in the predicted position ie an inclined orbit satellite.



Whilst relatively expensive, this device does offer the consumer true transparent operation. Unfortunately, the strength of the Robot gearbox limits the maximum dish size, with which it can be used to 3m. The unit is also not suitable for high wind areas. Nevertheless, it is anticipated future developments of the product will eliminate these shortcomings.

Actuator Cables

Both actuators and horizon to horizon mounts require suitable cabling to ensure reliable operation. Each motor requires 36V DC, and each sensor requires two conductors to carry feedback pulses to the dish controller. Conductors carrying the 36V DC need to be rated at 6 to 7.5 amps, to ensure minimum voltage drop over the entire length of the cable. A standard length is 25 metres, although any length, provided the internal resistance of the cable is low, can be used.

Conductors having a cross sectional area equivalent to 240V power cable can be used. Similarly automotive trailer cable is also suitable.

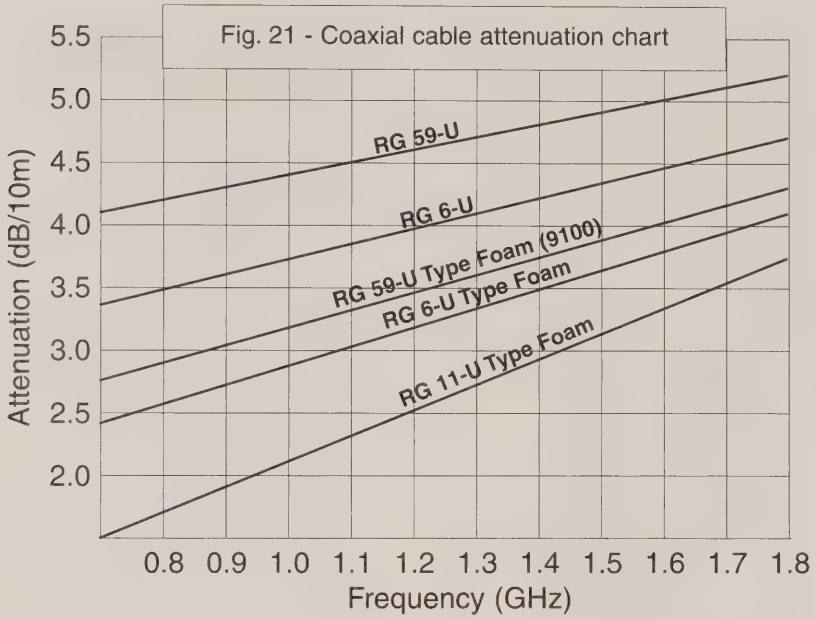
The conductors used for the feedback sensor are only required to carry 5 volts at a few milliamps, and so can be of lighter gauge. Ideally the sensor cable should also be shielded, to prevent miscounting. If shielded cable is used, the shield should be left disconnected at the controller end, and grounded to the dish at the far end.

In the event that shielded cable is not available, standard telephone twisted pair can be used. Care should be taken when using this kind of cable, as the conductors are solid, not multistrand, and can easily fatigue through flexing.

Coaxial Cables

The choice of cable used to connect LNB and receiver is important. The cable must be capable of carrying the downconverted, 500MHz block of frequencies, between 950 and 1450MHz. In addition, use of wideband LNBs has pushed the IF upper frequency limit to 2050MHz, so attenuation is also very important. Figure 21 shows attenuation figures for various types of 75 ohm cable.

Also, convention dictates that the cable impedance must be 75 ohms.



For short cable runs, up to 100 metres, RG-6/U cable is recommended. This type of coaxial cable has reasonable attenuation figures, and is compatible with "F" connectors commonly used on hardware (LNBs and receivers).

There are several grades of RG-6/U, and it is important to choose a grade offering 98% shielding. This is achieved during cable manufacture by using a copper braid shield (offering 40% shielding), and then adding a wrapping of aluminium foil. This combination improves the shielding to 98 or 99%.

The solid centre conductor of RG-6/U cable is copper clad steel. This ensures the centre conductor is strong enough to penetrate the gap between the spring loaded contacts in a type F socket. RG-6/U cable is therefore not as flexible as RG 59, another 75 ohm cable of similar physical dimensions, but not suitable for TVRO applications.

Experience dictates that only RG-6/U cable with foam dielectric is suitable for TVRO installations. Cable having a "honeycomb" air dielectric may have slightly lower loss, but the risk of moisture entry and retention in the honeycomb structure far outweigh this factor.

Once moisture enters a coaxial cable, it can be drawn by capillary action for many metres, causing the braid to corrode, and eventually break down. The coaxial cable in a TVRO system always has some DC voltage between the centre conductor and the braid (this voltage feeds the LNB). Any moisture between these two conductors will cause electrolysis, finally resulting in signal loss.

For longer cable runs, heavy duty cable, called RG-11 could be used. This cable has a larger diameter than RG-6/U, and the correct connectors must be used. Because this cable has a larger outside diameter, it is not as flexible as RG-6/U. Hence it is normal to use short RG-6/U "tails" to connect to the LNB and receiver ie at each end of the cable.

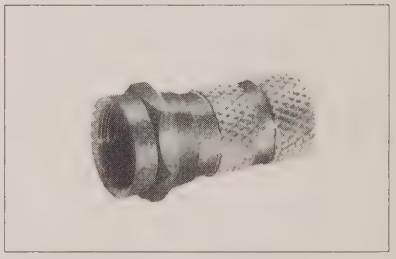
Due to the higher cost of RG-11, it is normally only used in commercial installations.

Connectors

Most of the IF signal connectors used in a TVRO system are known as type "F". Virtually all LNBs and receivers are fitted with type F sockets. Despite their cheap appearance, the 75 ohm male type "F" plug, designed to be fitted to RG-6/U coaxial cable, has quite good performance, in terms of impedance and insertion loss.

This is because the connector uses the metal case of the connector as a continuation of the coax cable shielding, whilst utilising the coaxial cable itself as the connector dielectric and centre conductor.

The simple screw on F type plug is easy to fit, requires no special tools, and has good performance. Photo below shows such a connector.



There are special F type plugs for the larger diameter RG-11 coaxial cable. To successfully fit these connectors, either a special crimping tool, or a soldering iron is needed, depending upon the type.

Despite what the purists

may say, in many cases, it is a far cheaper and practical solution to use a line amplifier (to compensate for coaxial cable loss over a long cable run), than to purchase higher quality cable.

There are a number of F series adaptors in use today, including the F81 coupler (female-female), and the F female to BNC male, used to connect a standard F plug to a Plessey 2000 series BMAC receiver.

Weatherproofing

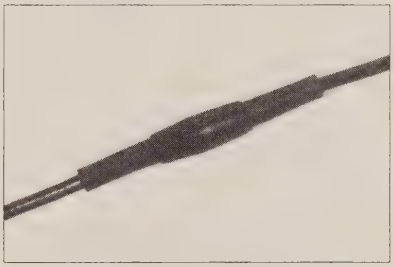
Where an F type connector is used externally, it is very important to take steps to ensure that moisture cannot enter the connection. There are two methods commonly used to ensure the ingress of moisture does not occur.

Self amalgamating tape is a rubber based self adhesive tape, similar in appearance to electrical insulation tape. What makes this tape so useful is the amalgamating properties between successive layers. By winding several layers of the tape around both the male and female components of the termination, the tape forms an adhesive bond to both the connectors and to itself, forming a waterproof barrier.

Self amalgamating tape, after application has a life of many years, and can be removed (with some difficulty), if component replacement is required, by slitting the covering with a sharp knife.

Another effective method of weatherproofing an F type plug connection, is to use a rubber boot. This is particularly effective where there is some likelihood that the cable join may require inspection at a later time.

An automotive spark plug cover forms a perfectly waterproof seal over RG-6/U coaxial cable, and is pliable enough to enable it to be slid over an in line F type plug. Where two lengths of cable are to be joined together,it is necessary to use a cable coupler (female to female) and two rubber boots. Pushing the rubber boots together forms a weatherproof seal. If the joint is to be left in the open,exposed to rain, it is also necessary to seal the junction of the two boots, with a layer of self amalgamating tape.



LNB Covers

In addition to the use of self amalgamating tape and rubber boots, it is also a wise idea to use an LNB cover. This effectively gives protection to the LNB, feedhorn and their electrical connections.

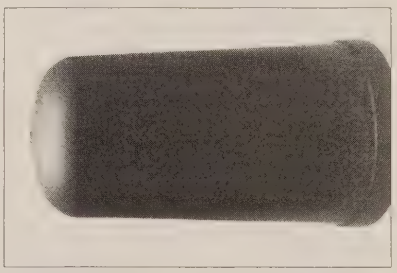
The size of LNB covers varies, depending upon the size of the LNB and feedhorn. There are two basic sizes, one each for C and K bands.

Most large aperture dishes (2.3m and larger) are supplied with an LNB cover which is large enough to cover not only the LNB, but also the complete feedhorn assembly. This is a great advantage when using a dual band feedhorn, where multiple coaxial connections are made to the LNBs. Quick and easy removal of the cover makes maintenance a simple task.

This type of cover comprises two parts, the "nose cone" and the mounting ring. The mounting ring is secured by the feedarm bolts, and fits between the feedarm flanges and the scalar ring of the feedhorn. Most larger dishes use 4 feedarms, so the mounting ring is thus held by four bolts. The "nose cone" is secured to the mounting ring by 4 plastic clips, spaced at equal distances around the perimeter of the mounting ring.

When a feedhorn cover is not available, a bucket can be used to cover a C band feedhorn, and a plastic softdrink bottle (after removal of the neck), can be used for K band feedhorns. Cable ties can be used to secure such homemade covers.

Although normally black in colour to match the dish, repainting the feedhorn cover white or some other light colour will keep the LNB up to 40°C cooler than if it were



exposed to direct sunlight.

Line Amplifiers

Line amplifiers are used to overcome coaxial cable losses. Line amplifiers are normally powered up the coaxial cable

by the receiver, and hence could be fitted anywhere in a long cable run.

A common misconception is that a line amplifier will improve the reception of a satellite signal. This is untrue. The carrier to noise figure of any TVRO system is set by the performance of the dish, LNB and feedhorn. All a line amplifier does is further amplify the output of the LNB, to overcome cable losses. It cannot improve the C/N ratio, or picture quality.

Most receivers will accept an input signal level from -30 to -60dBm. It is important to present the correct signal level to the satellite receiver for optimum results.

Feeding the receiver with more than -30dBm and the video produced will appear "grainy". Feeding the receiver with less signal than -60dBm, and the picture will become noisy.

Most LNBs produce an output level of around 0dBm. So it can be seen that, even if 30dB of level were lost in the coaxial cable, there would still be sufficient signal level at the receiver.

The worst case attenuation of RG-6/U coaxial cable (at 2000MHz), is about 45dB per 100 metres. Even in this case, no line amplifier would be needed, if the coaxial cable runs directly from LNB to receiver.

However, every time an IF splitter is used (to feed another receiver), attenuation is added to the system. A two port splitter introduces 4.5dB of attenuation, so it can be seen that, in some circumstances, where a long cable run and multiple splitters are used, a line amplifier might be necessary.

Also, if the satellite receiver is insensitive (like a Plessey 2001 BMAC receiver), some extra drive might be needed.

Line amplifiers of 10dB and 20dB gain are available. Where a line amplifier is used, it should be placed in the coaxial cable, where it can do the most

use.

For instance, a 10dB line amplifier could be fitted after 25 metres ie, after 10db of loss has occurred in the cable. It is important not to fit the line amplifier too close to the LNB, where it could be (over) driven into compression.

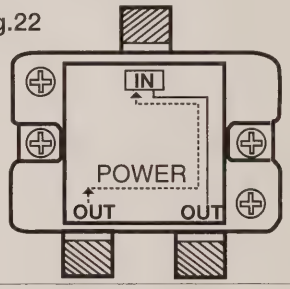
Line amplifiers also add noise to a receiving system. The noise figure of a typical line amplifier is atleast 6 dB. As there is no advantage in adding noise to a system, line amplifiers should only be used to overcome cable loss.

Splitters

A splitter is a device that can be inserted in the coaxial line between receiver and LNB, to allow the connection of multiple receivers to the one dish. Splitters are available configured from 2 to 8 outputs, for domestic use. Normally one "port" of the splitter allows DC voltage to pass, ensuring that the LNB is always powered. The other ports can then be connected to as many receivers as desired.

Another type of splitter uses diode switching to switch the output port fed with the highest DC voltage to the LNB. This type is often called an

Fig.22

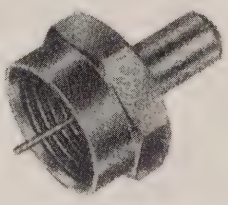


"intelligent" splitter.

Because a splitter must operate at frequencies up to 2000MHz, the internal circuitry uses minute components, and is housed in a metal, weatherproof enclosure. Fig 22 shows a "2 way" splitter.

Terminators

A terminator is a coaxial 75 ohm resistor, used to terminate unused ports on a splitter. This is necessary to ensure that signal reflections which would degrade performance, do not occur, and to ensure system impedance is maintained. This is very important in digital systems where signal reflections at the receiver



75 ohm termination

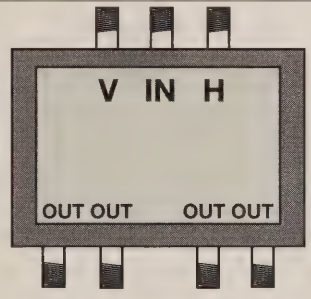
input must be minimised.

Terminators must not be used on splitter ports carrying DC voltage. Not only will the 75 ohm terminating resistor be

destroyed, it is likely the satellite receiver supplying the voltage will also be damaged.

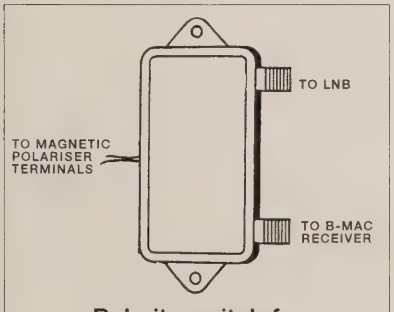
Polarity Switches

There are two types of commonly used polarity switch. One type allows the connection of two LNBs which when used with an orthomode feedhorn, allow the same dish to receive signals having the opposite polarisation. This



14/18 V polarity switch for two separate input signals

type of switch allows connection of multiple receivers, and utilises the 14/18 volt DC switching capability of modern receivers to switch between the two LNB input signals. This way, multiple receivers can be



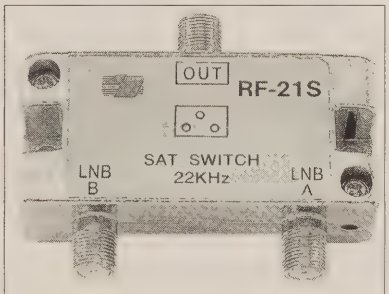
Polarity switch for B-MAC receiver

connected to one dish, each receiver retaining polarity control.

A second type of polarity switch is used to generate a switchable DC voltage (14/18 volts) in order to operate a dual polarity LNB. This type of polariser requires a 5 volt TTL source, to act as the polarity switching "trigger". Typically, this polariser is used with BMAC receivers (Scientific Atlanta and Plessey), where a TTL output is available.

22KHz Switches

One common method employed to connect multiple RF inputs to a single input receiver is to use a "22KHz switch". This type of switch will only operate with satellite receivers capable of generating a 22KHz pulse stream. The pulse stream is superimposed on the DC voltage feeding the LNB, and does not affect reception performance. The external switch is housed in a



22 KHz switch

weatherprooof enclosure, and has an inbuilt 22KHz detector which switches input ports when it detects the pulse stream. This way, either of 2 inputs can be selected by preprogramming the 22KHz tone to be either on or off, depending upon which input source is desired.

As most modern satellite receivers already have two input ports as a standard feature, the 22KHz switching facility allows expansion for up to 4 inputs.

Dual Band Combiner

A result of the introduction of the "one cable solution" LNB is the dual band combiner. This small metal box contains a 2 port splitter, 600MHz local oscillator, mixer and output amplifier. One port (bypass), allows the output signal of the LNB to pass through the combiner without change. The second (convert) port routs the signal to a mixer coupled to the 600MHz oscillator, providing a second 500MHz wide band of output frequencies, 600MHz removed from the first.

In this way, the dual band combiner can be used not only to combine C and K band signals, but also to combine two C band or two K band signal sources.

The receiver with which the combiner is used must be capable of allowing the user to reprogram the LNB local oscillator oscillator (and corresponding IF band frequencies) expected by the receiver.

To combine two K band signals local oscillator frequencies of 11300MHz and 10700MHz can be used. Similarly, to combine two C band signals 5150MHz and 5750MHz are used.

Similarly, to combine C and K band signals, 5150MHz and 10700MHz (or 5750MHz and 11300MHz) can be used.

Receivers

Initial frequency conversion from either 4 GHz or 12GHz to the first IF (950-1450MHz) is done in the LNB (Low Noise Block converter) which is essentially a low noise amplifier and frequency converter in one package. This converter produces a block of output frequencies 500MHz wide, which is then fed via coax cable to the receiver.

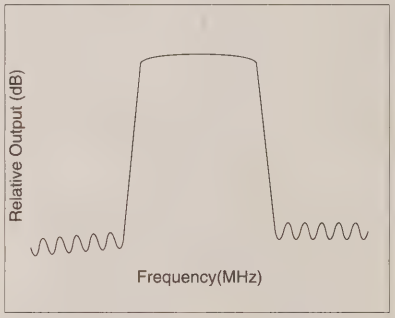
The receiver contains the second frequency converter, and a local oscillator which is either manually tuned or stepped using a synthesised PLL (phase locked loop) circuit. This provides a second IF often at 479.5MHz, which is then amplified, filtered and detected using a balanced demodulator to provide a baseband output. In a modern receiver, most of this signal conversion takes place in the tuner module.

This baseband output contains all the video and sound subcarrier information. After further filtering to remove certain video components from the audio subcarriers, the video is processed using the standard video detector. The audio is demodulated using either a PLL capable of covering 5-8MHz or a quadrature detector operating at 10.7MHz. This second approach allows the use of standard wide band FM filters but does not allow any flexibility when detecting either very wide or very narrow audio subcarriers. Figure 12 shows the block diagram of a typical satellite receiver.

To maximise satellite use, a number of transponders or satellite channels are allocated within the downlink pass band. These may be either full or half transponders having a band width (in the case of Intelsat) of either 36MHz or 18MHz respectively. Because the signals are FM, every effort should be made to obtain a signal level that is sufficient to take the receiver into limiting, i.e. above threshold. This means making the receiving system as efficient as possible.

One part of the receiver that plays an important role is the IF filter. In modern receivers, this is an integral part of the tuner module. The type of filter used is called a SAW (surface acoustic wave) filter, and is characterised by very steep skirts. Diagram (right) shows this.

The bandwidth of such a SAW filter is quite important. Obviously, if the bandwidth of the filter is 36MHz and the band width of the signal being received is 18MHz, a considerable amount of noise will also pass through the filter, degrading the signal to noise ratio (S/N ratio) of the receiver.



If a receiver with a bandwidth of 18MHz is used instead then there will be an improvement of 3dB in the S/N ratio. In practical terms, a half transponder signal can be received using an IF filter having a bandwidth as narrow as 10-12MHz. The trade-off is less intense colour, slightly noisy audio and often tearing of superimposed lettering, and black or white sparkles in saturated colours, especially bright blue and red. These effects occur when the FM carrier from the satellite is modulated heavily enough to move the instantaneous frequency outside the pass band, of the IF filter.

As might be expected, the video signals that fall into this category are those which contain brightly saturated colours and sharp contrast divisions. The lower colour saturation, accompanied by lower modulation levels and overall "softening" effect of film reproduction means that movies are the least prone to this type of distortion.

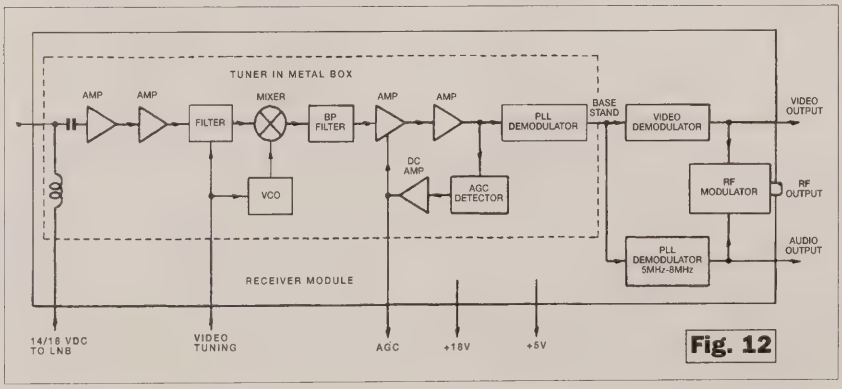
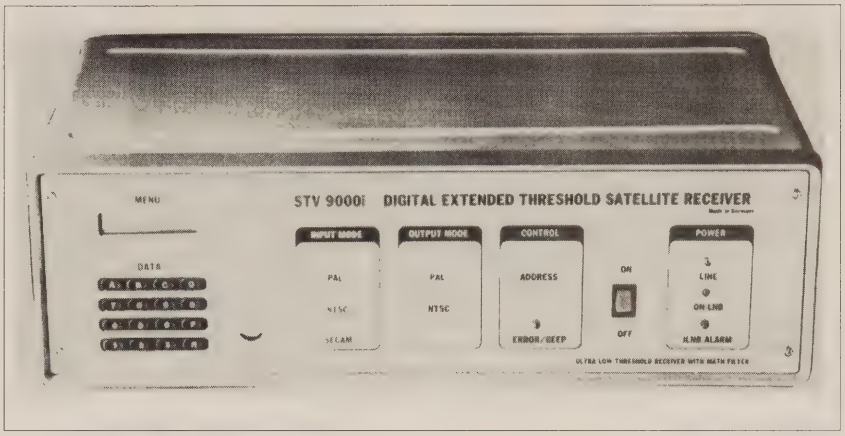


Fig. 12

Despite these drawbacks, it is important to realise that earth stations must be designed to maximise the incoming signals, the level of which is fixed. Every receiver has a threshold point expressed in dB C/N. As the C/N falls below threshold the video becomes increasingly noisy.

The threshold of the receiver is defined as the point at which the relationship between the Carrier to Noise ratio (C/N) of the incoming signal and the signal to noise ratio (S/N) of the resulting video becomes nonlinear. Above the threshold point, each 1dB increase in C/N will cause a corresponding 1% increase in S/N of the video signal. However, when operating below threshold, a 1dB increase in C/N will cause several dB improvement in the video S/N. As the FM detector is nonlinear, it is easy to understand when operating in the nonlinear portion of FM threshold, impulse noise is introduced at a rapid rate.



Low Threshold Receivers

Most modern receivers are sophisticated microprocessor controlled units, employing the combination of a low noise figure tuner module and switched IF bandwidth reduction to improve recovery of weak signals.

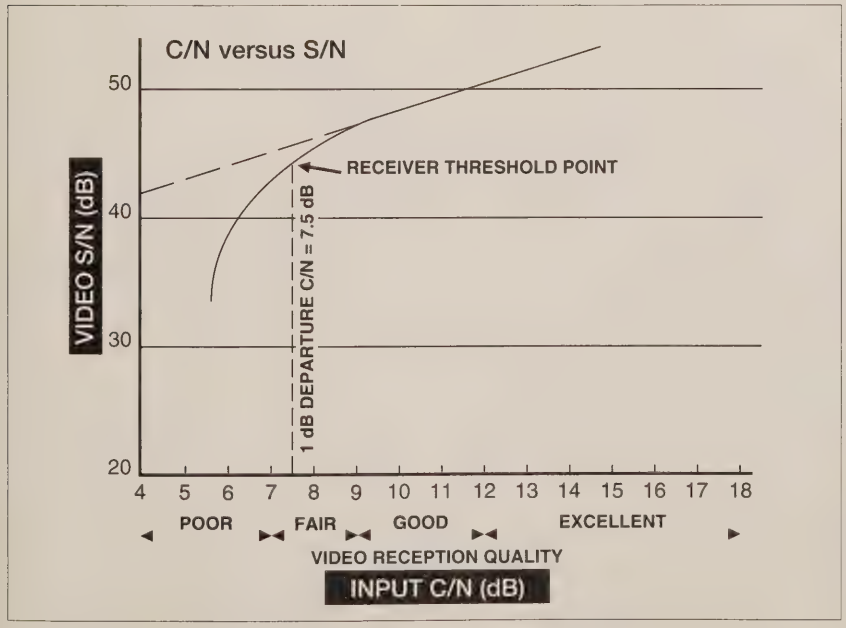
However, a manually tuned satellite receiver is still a good and economical introduction to satellite TV reception. For those inclined to "do it yourself", the kitset receiver shown (on right) was introduced in 1995.

During 1994/5, a number of commercial low threshold receivers were introduced to the world market.

The main advantage of such receivers is the ability to memorise IF bandwidth settings for individual satellite channels, making operation virtually transparent to the end user.

Many modern low threshold receivers also have sufficient micro-processor power to memorise dish positions.

Dedicated low threshold digital receivers are available at huge prices. A digital low threshold receiver having a threshold of 0.5 dB is available for approximately US$5000, and has apparently been used in affluent Middle Eastern countries. Despite such performance claims, no such receiver has ever been seen in the South Pacific.



Kit Receiver

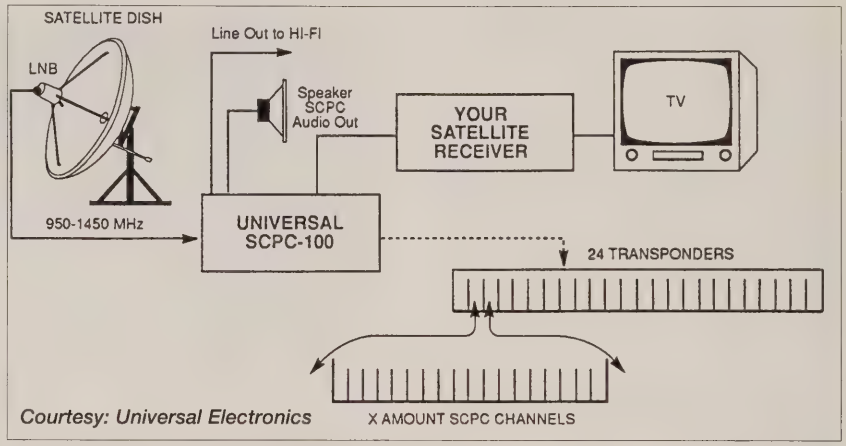
Radio Reception – SCPC

Television is not the only service available to enthusiasts on Australian satellites. For many years, prior to the introduction of digital satellite links in 1994, many radio services were accessible on the Aussat A series satellites. Generally, these broadcasts were dedicated links from capital cities to regional radio stations.

The OPTUS B series of satellites utilises single channel per carrier, or SCPC as it is commonly known, to distribute aircraft radio links. These links are narrowband FM, and can be readily demodulated using a UHF scanning receiver. The Optus B series transponder chart shows SCPC services residing on transponder 9. Calculation of the IF frequencies at the limits of the transponder frequency shows that the system LNB produces an IF output from 995 to 1035 MHz, a block of frequencies capable of supporting many NBFM signals.

By connecting a suitable scanning receiver capable of covering the above frequency range, and resolving NBFM, to the IF output of the LNB (via a DC isolating splitter), SCPC radio reception is easily achieved. Of course, the use of a PLL stabilised LNB ensures that radio frequencies entered into the scanner memory, can be accessed at any time, regardless of outside air temperature. Non stabilised LNBs drift, making memory operation of a scanning receiver difficult.

Dedicated SCPC receivers are available, such as the



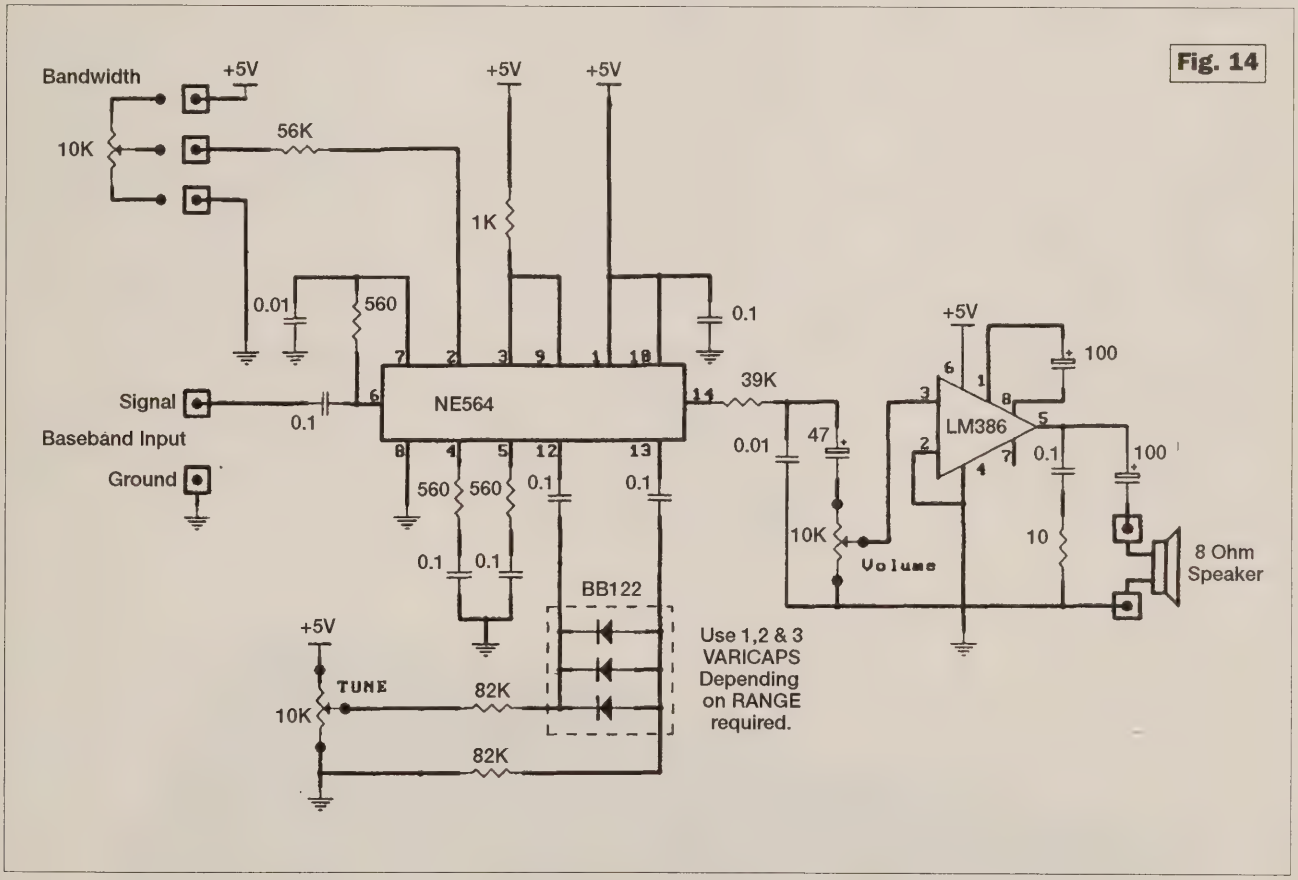
Courtesy: Universal Electronics

UNIVERSAL SCPC-100. This unit allows series connection of the coaxial cable from the dish, allowing both the SCPC receiver and the TVRO receiver to be connected to the one feeder cable. The LNB is fed, as it would normally be, by the DC voltage supplied by the TVRO receiver.

Baseband Services – FM2

Although now largely replaced by digital delivery systems, one very economical "audio only" satellite delivery system is Omnicast utilised on the Optus B1 satellite until 1997. Omnicast, or "FM2" is so called due to the superimposure of an FM signal on an FM subcarrier. These signals are contained in the "baseband" part of the video signal,on a satellite transponder and can be demodulated via the unfiltered baseband output. Services using these frequencies include "muzac", in house merchandising services, and others. A baseband decoder allows tunable coverage of these services from 200KHz to 2MHz.

Figure 14 shows the circuit diagram of a simple two chip decoder, which can be connected to baseband output of a satellite receiver.



Internet via satellite

Although much has been written, particularly in computer magazines regarding delivery of Internet services by satellite, no reliable, fast system has yet been marketed in our part of the world.

The basic requirement for two way communication between Internet service provider and domestic user makes true satellite delivery a reality only for those investing in expensive VSAT systems, far removed from the reach of the typical Internet "surfer".

Some compromise systems have been floated, with varying degrees of success. All such systems rely on the fact that the information request from the user occupies little bandwidth, whilst the information flowing from the Internet to the user may require large amounts of bandwidth.

Thus some advantage can theoretically be obtained in terms of download time (and subsequent cost) by routing the information request via the normal telephone line and routing the return data, which uses the most bandwidth and can take the most time, by satellite.

Unfortunately, satellite delivery time delay, error correction protocols, and repeat data requests, make this an imperfect system.

One approach by german company Net On Air was to simply operate a huge cache of Internet sites, and sequentially broadcast this data "piggy backed" on a digital satellite television signal.

Thus the user could turn on his computer at any time, activate the Net On Air software, and download over several hours, hundreds of Internet sites, selected by NOA, as being of interest.

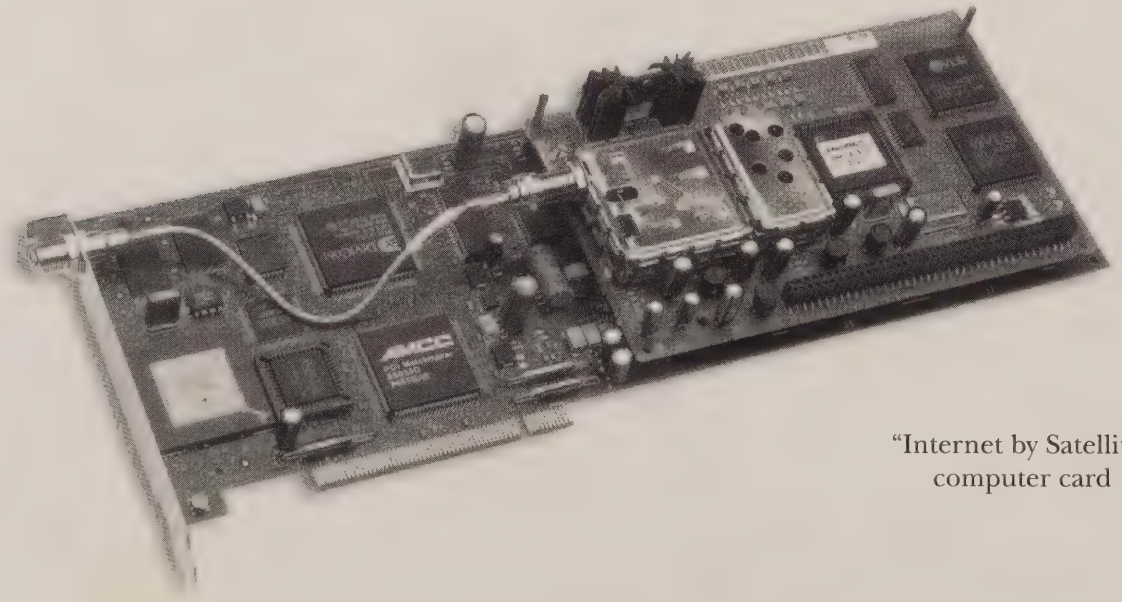
The user could then simply review and discard unwanted sites. No return path to the ISP is required. This system was trialled in 1997 and speeds approaching ten times that achievable over telephone lines was obtained.

Although technically capable of making the system work, the licensees of the system in the Pacific became embroiled in numerous legal battles on commercial issues, and the system never became operational in the long term.

Other attempts at combined terrestrial/satellite systems have resulted in varying degrees of success.

Kuwait based operator Zaknet utilises a transponder on Asiasat 2 for their domestic Internet delivery system, and The Internet Group operate a successful commercial delivey system on the Panamsat 2 satellite. AAP have announced that they too will operate a system for domestic users on Panamsat 2.

Domestic systems utilise a proprietry MPEG decoder card in conjunction with the users computer and satellite dish.



"Internet by Satellite" computer card

Satellite related internet sites http:// (address)

Broadcasters/Programmers address

AUSTRALIA TELEVISION
www.austv.com.au

AFRTS
www.dodmedia.osd.mil/afrts-bc/services

BBC
www.bbc.co.uk/

BLOOMBERG TV
www.bloomberg.com/welcome.html

CBS
www.cbs.com/navbar/news.html

CCTV
www.cctv.com/cindex.htm

CNN
http://cnn.com

CNBC ASIA
www.abn.com.sg

C-SPAN
www.c-span.org/

CTN
www.ctn.net

DISCOVERY
www.discovery.com

DEUTSCHE WELLE
www.dwelle.de

ESPN
www.espn.sportszone.com

EWTN
www.ewtn.com

GMA
www.gma.com.au

GWN
www.com.au

IMPARJA
www.imparja.com.au

MTV ASIA
www.mtvasia.com

MTV
www.mtv.com

MULTICHOICE
www.multichoice.com.za

NBC
www.nbc.com

NETWORK 7
www.seven.com.au

NETWORK 9
www.ninemsn.com.au

NHK
www.nhk.or.jp

NTV
www.ntv.ru

ORT-1
www.ortv.ru

RADIO AUSTRALIA
www.abc.net.au/ra

RAI
www.raiinternational.rai.it

RCTI
www.rcti.co.id/

RFI
www.rfi.fr

RTPi
www.rtpi.rtp.pt

SBS
www.sbs.com.au

STAR TV
www.starv.com

TCS
www.tcs.com.sg

TNT
www.tnt-tv.com

TPi
www.tpi.co.id

TV CHILE
www.tvn.cl

TVe1
www.rtve.es

TVNZ
www.tvnz.co.nz/sat

TV5 THAILAND
www.baanthai.com/globaltve.shmtl

TV5
www.tv5.org

VOA
www.voa.gov

ZDF
www.zdf.com

Zee TV
www.zeetelevision.com

Satellite Operators/Manufacturers

ASIASAT
www.asiasat.com

ESA
www.esrin.esa.it

HUGHES SPACE
www.hughespace.com

INTELSAT
www.intelsat.int

JAPAN SATELLITE SYSTEMS
www.jss.co.jp

MABUHAY
www.mabuhaysat.com

OPTUS
www.optusvision.com.au

ORION
www.orionnetworks.net

PANAMSAT
www.panamsat.com

SATELLINDO
www.satelindo.co.id

SHINAWATRA SATELLITE
www.shinawatra.co.th

THAICOM
www.thaicom.net

Satellite Launch Organisations

ARIANE
www.arianespace.com

Encryption Systems

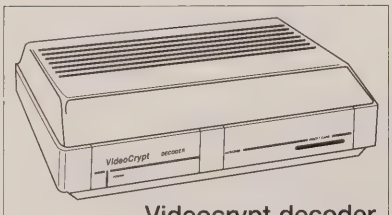
Videocrypt

Videocrypt is an encryption system designed primarily for use with the PAL transmission mode. It was developed in 1988 by Thompson Consumer Electronics in France, and Professor Adi Shamir of the Weitzmann Institute of Science in Israel.

Videocrypt is used by the terrestrial "Sky TV" service in New Zealand, and was used by Television Oceania, a Japanese language narrowcaster utilising the Optus B3 satellite, until the termination of service in March 1996. PNG broadcaster EM TV, operating on the Gorizont 30 satellite (142.5° E) used the Videocrypt system from September 1996 through 1997.

Further afield, the system is used by Sky Television in the UK.

Videocrypt is now so robust it is possible to record the encoded signal and play it back for decoding. Professor Shamir came up with the concept of zero knowledge transfer, which has been explained by Thompson's R and D lab as follows:



Videocrypt decoder

"To decode the signal, the code coming down from the satellite with the program cooperates with codes stored in the decoder and codes stored in a smart card, to create a digital signature. There is no single secret code to crack".

Videocrypt achieves what many people had previously thought impossible. It encrypts a PAL signal with almost total security yet without noticeably degrading picture quality after decoding. Also, although address codes are broadcast with the picture signal, they are not essential to authorisation. The key role is played by the smart card with its built-in computer and memory chip. Hence, there is no need to leave receiver switched on to standby unless it is for some other reason, to keep the LNB stable, etc.

Videocrypt operation is as follows. Before transmission, each horizontal line of the TV picture is cut into two halves and these are rotated so that the second is transmitted before the first.

There are several hundred possible cut points in each line and these continually change. On a conventional TV set, the received picture appears as a meaningless jumble of horizontal streaks. This is the technique known as "cut and rotate". The decoder delays each line of the picture just long enough for the two halves to be inverted and joined to reconstruct the original picture line. However, the decoder can only do this if it receives the correct instruction on where each line has been cut.

Part of this vital instructional key, is transmitted like Teletext as a digital code carried in the vertical blanking interval. The code in the vertical blanking interval has a slower data rate than the teletext. This is to make it more robust. The other part of the key is stored in the solid state memory of a smart card. Once the card has been fitted to a decoder, the decoder will degroup pictures until the transmitted code changes and the subscriber inserts a new card to match the new code.

The card system works by chaining handshakes. All decoders are the same, like an unprogrammed computer. Each card carries an identification number matching the subscriber. When the first card is initially inserted into a new decoder, its number is stored and the decoder authorises the card for use. The authorised card can then be used in any decoder. When the card expires, the new one must be first inserted into the home decoder which checks the number of the new card and authorises it for use in any decoder and so on.

Each decoder, therefore only works while it has an authorised card. When the transmitted codes change, the user needs a new card. Because each card is coded to match the identity of the subscriber, if a card is lost during delivery or stolen it can be easily disabled through an instruction transmitted in the satellite signal which can permanently disable that single card.

Cryptovision

The Cryptovision system is similar to "Videocrypt", as it uses a similar cut and rotate system. Each active line of video is cut at a random point and the two line segments

formed are interposed. The first part of the line is shaped with a sine squared ramp, and the cut point is shaped with overlapping sine squared and cosine squared ramps, added together. The last part of the line is shaped with a cosine squared ramp. This means that in the event of the rotated portions of the line forming a transition from black to white, (or reverse white to black), on adjacent pixels, that the bandwidth required is under 5MHz instead of the 25MHz or so normally required.

The audio signal is also scrambled using spectral inversion. The Cryptovision system is capable of addressing up to 128 million decoders in the same system. There is a security processor in each decoder, capable of processing the algorithms for decoding the signal and the serial number of every individual decoder.

The encoder transmits a "control message" to all decoders once every two seconds, as well as decoder "entitlement messages", which are sent at a rate between 17000 and 22000 per hour.

In Australia, the Cryptovision system has been used by the Victorian Department of Secondary Education to transmit educational programs to schools in Victoria.

Vidiplexing

Vidiplexing is a system developed by Thomson CSF, which allows two independant video frames to be transmitted in interlaced format, simultaneously, as a type of analogue compression. Although used infrequently since the introduction of MPEG, the system was used extensively on Intelsat 508 later replaced by I511 then I701 by several commercial networks in Australia.

The system utilises two sequential fields of a TV signal (normally carrying identical video information) to carry

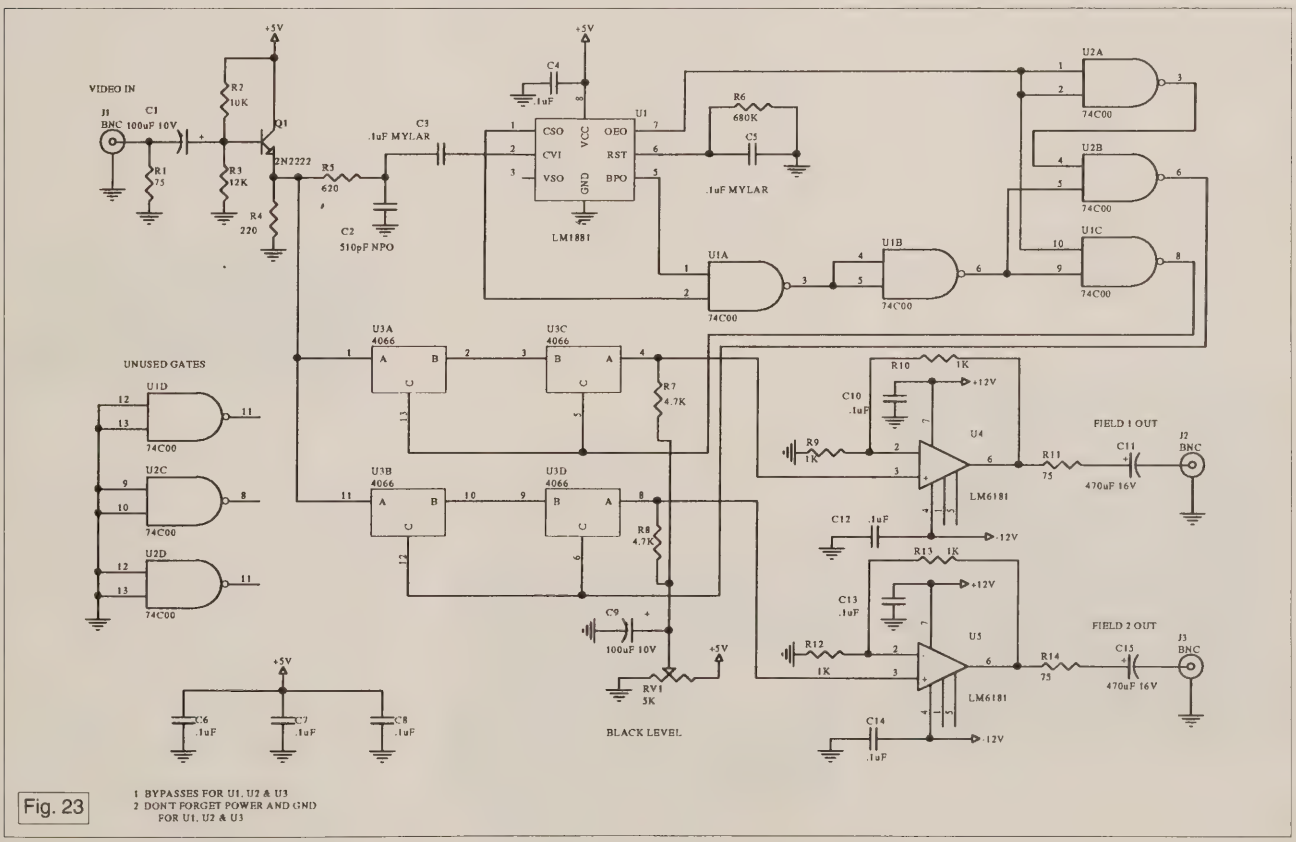


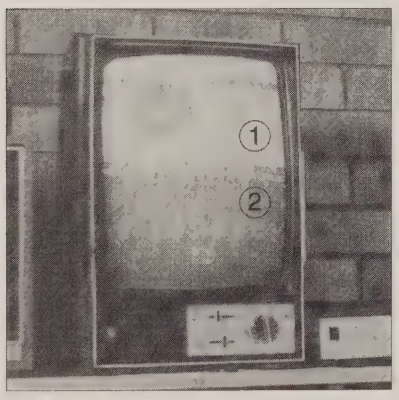
Fig. 23

1 BYPASSES FOR U1, U2 & U3
2 DON'T FORGET POWER AND GND FOR U1, U2 & U3

two separate and different video signals. In effect, it allows two pictures and their accompanying audio subcarriers to be transmitted at once, eliminating the need for additional transponder hire for the second program.

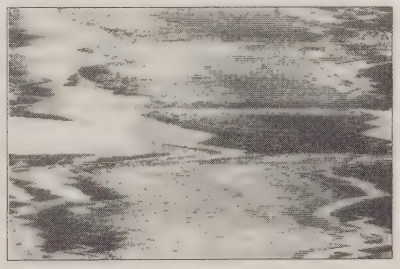
Figure 23 (previous page) shows the circuit diagram of a vidiplex decoder. Even though this type of decoder can be built very cheaply, it still produces an annoying picture flicker, which can effectively be removed using a digital field store unit. Digital multistandard converters can perform both this and video standards conversion.

Another inexpensive method of viewing both frames simultaneously, is to use a standard video monitor, and rotate the yoke 90 degrees. By then rotating the monitor through 90 degrees, so that it is sitting on its side, the two frames will be displayed vertically, provided there is sufficient range in the vertical hold adjustment.



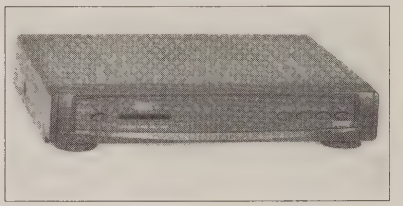
B-MAC

B-MAC encryption offers hard video security through a technique known as line translation scrambling. Each line of video information is delayed by several microseconds creating B-MAC's characteristic diamond shaped pattern. Only receive stations equipped with a B-MAC decoder can descramble this signal. Such decoders are addressed by a packet of data contained in the vertical blanking interval of the B-MAC signal. The B-MAC horizontal blanking interval contains up to six digitally encrypted audio channels on one spare data channel. In addition, B-MAC provides an increased level of signal performance at low carrier to noise levels when compared to PAL. This results in the use of smaller diameter dishes, compared to other transmission formats. B-MAC sequentially transmits colour information in one third of the active scanning time of each frame, and black and white information in the remaining two thirds of the active scan time. This prevents chrominance and luminance interference, providing improved video performance.



By displaying the video vertical blanking interval, individual lines which carry signals can be observed. Line one is used for the digital clock recovery signal whilst line two carries digital sync, line three is used for the transmission of system data, lines four, five, six, seven, eight and nine are used as address lines for data packets whilst lines ten, eleven, twelve, thirteen, fourteen and fifteen are used to transmit teletext packets. The horizontal blanking interval can contain as many as six 204 kilobytes per second (kb/s) digital audio channels and one 63 kb data channel.

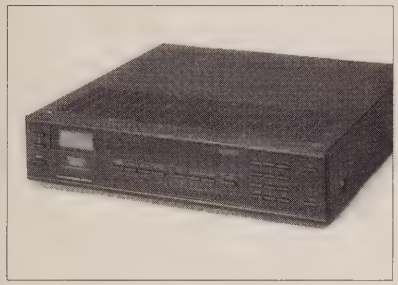
Until late 1997 B-MAC was utilised by Indonesian broadcaster INDOVISION to carry subscription programming to authorised viewers in the region. The B-MAC decoder used for this service is the CDE-2000, which utilises the baseband output signal from an analogue satellite receiver.



In Australia the B-MAC utilised to carry television and radio services to the outback will be replaced by the Optus "Aurora" digital platform.This service is called HACBSS (Homestead and Community Broadcast Satellite Service). Programming is provided by the ABC and SBS along the east coast. In addition, commercial broadcasters, operate to certain geographical areas, such as QTV (Queensland), Imparja TV (Northern Territory), and the Golden West Network

(Western Australia).

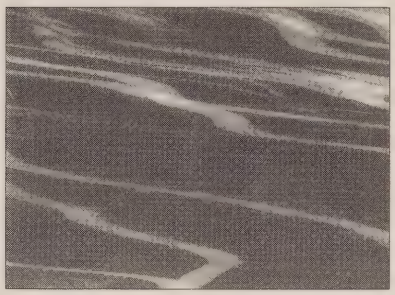
In addition, B-MAC is also used by various closed user groups, such as the Queensland Government, the Department of Social Security etc. The only B-MAC receiver available at present for these services is the Scientific Atlanta #9708, pictured below.



With the introduction of digital video compression services the future of B-MAC would optimistically seem to be limited to the next 12 months

E-Pal

In addition to the HACBSS services carried on the Optus satellites, commercial networks distribute their programming using a unique encryption system called E-PAL.



The use of this system is twofold: it enables television networks to comply with government regulations ensuring that reception of commercial TV signals by satellite is prevented, thereby protecting regional TV stations and ensuring their continued operation (and income from local advertising), and it also provides enhanced dynamic range and fidelity through the use of ADM (adaptive delta modulation).

E-PAL works by digitising the audio through the use of ADM, and by corrupting the vision signal by inverting the video, and removing the sync signal. Satellite enthusiasts have produced a variety of homebuilt E-PAL vision decoders, similar to the circuit shown in figure 24. Unfortunately, no economical decoders are available to

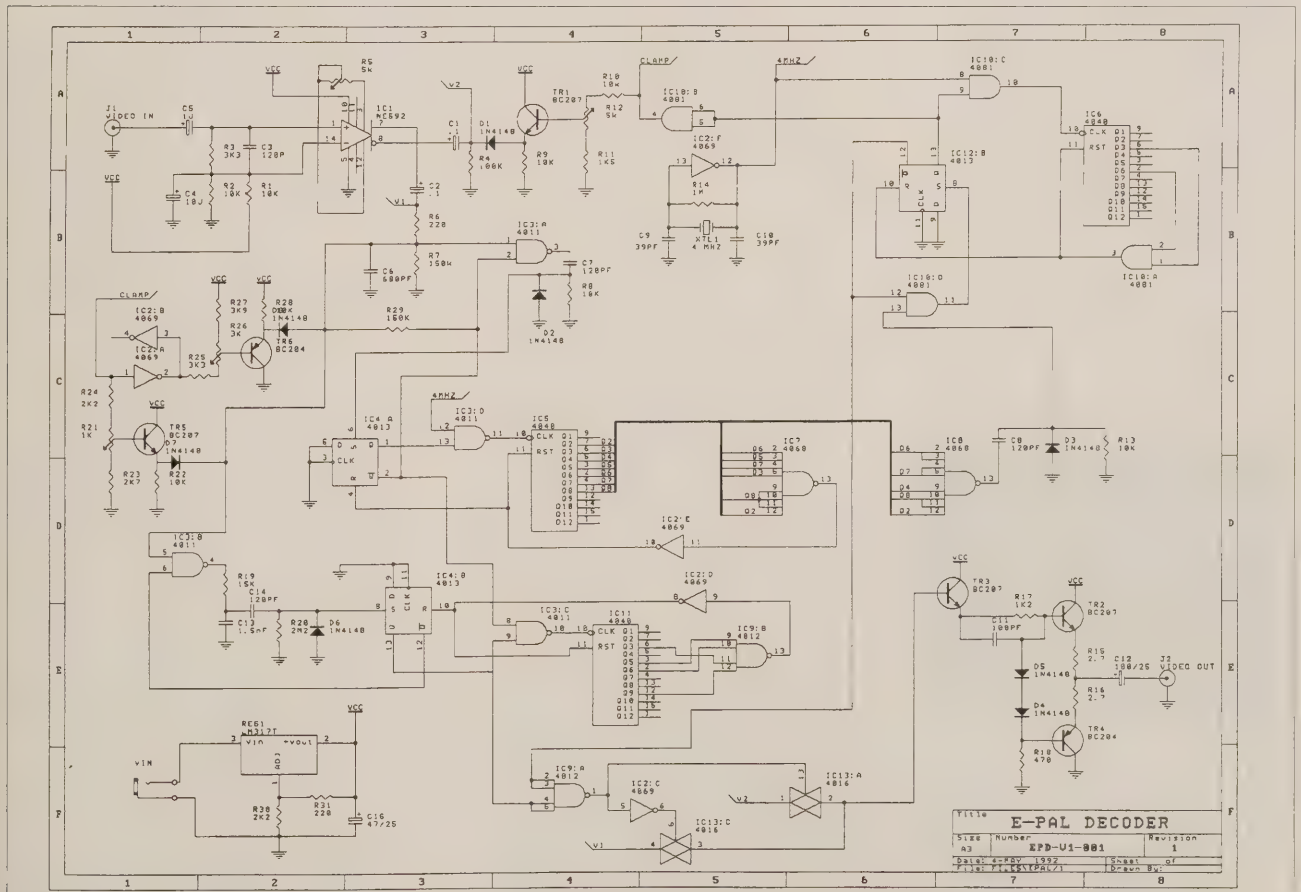


Fig. 24

Courtesy: Julie Kentwell VK2XBR

produce audio from E-PAL.

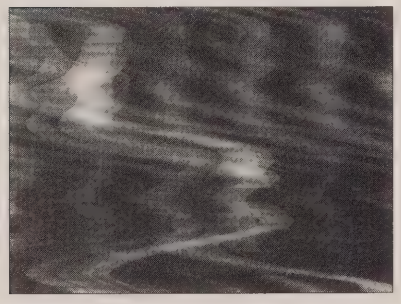
It has been shown that the combination of terrestrial TV sound (even though the picture might be unrecognisable), and E-PAL vision by satellite, can provide an imperfect solution for those unable to view terrestrial commercial television signals.

Professional E-PAL vision decoders (some allow teletext reception) are available from most reputable satellite dealers.

Sinewave Sync Shifting

This is a relatively simple encryption system, employed by at least one operator on the Agila 2 satellite. The video signal is inverted, and a sinewave at either 60Hz or a multiple of 60Hz (in countries using NTSC, such as the Phillipines) is added to the inverted video.

The result is deflection of both the vertical and horizontal and sync signals into the luminance signal, making it impossible for the video monitor or TV set to lock to the frame. Photo shows a sinewave sync shifted signal.



Video Compression

Video Compression

Video compression is the technology used for satellite delivery of the Australian "Pay TV" service. The main advantage of video compression is the operating cost. If 24 video compressed channels can be transmitted by satellite using just a single transponder, then each channel operator is up for one twenty fourth the cost of a full transponder. As the single transponder cost per 12 months is likely to approach $7 million, this is a considerable saving.

Digital video compression for broadcast services offers the prospect of vastly improved transmission capacity at greatly reduced cost. MPEG-2, the latest compression standard, assigns the highest priority to image quality, and is designed to handle full screen, full motion images, at data rates of up to 40Mbits per second.

Almost all of the work to set an international video compression standard has been done by the Motion Picture Expert Group (MPEG), the International Standards Organisation (ISO), and the International Electrotechnical Commission (IEC). In April 1993, after 4 years of work, the 230 MPE members from 18 countries agreed on the architecture of MPEG-2. In November 1994, MPEG-2 was designated an international standard, and already US, European, and Japanese chipmakers have started chip sampling.

For those sceptical about data compression and the results with MPEG-2, the results are astonishing. MPEG-2 can compress images of much higher quality than those of TV broadcasting. MPEG-2 is a completely different approach to traditional data compression, which aims to use as little bandwidth as possible, whilst providing the highest possible resolution.

The whole concept of data compression relies on eliminating the repetitive bits of information in a moving picture that do not add to picture content. By eliminating as much unwanted data as possible, narrower bandwidth can be used. The first compression standard, intended only for still pictures, and subsequent storage on either magnetic or optical disk, was JPEG, developed in 1991.

Subsequently MPEG-1 was developed, assuming that compressed data would be stored on a compact disk, with a transfer speed of 1.2Mbits per second. This allows reproduction of video, at quality almost equal to VHS tape. By updating data at a sufficiently high rate, smooth flowing motion can be achieved. At data rates below 1.2Mbits per second, jumpy motion cannot be avoided, making systems using this low rate of compression, ineffective for fast moving programming such as sports etc.

MPEG has a layered structure. The outer layers provide the system functions, synchronisation and multiplexing, necessary because of the multiple data streams used in the system. The inner layers define image and audio compression mechanisms.

The MPEG1 system works by recognising that pixels change little from frame to frame in moving video images. The system takes a reference frame, compresses it, performs a transform and then quantises the frame. This four step procedure retains all the information, thus maintaining reasonable quality. The system then takes a new reference frame, every quarter of a second or so, depending upon the level of pixel movement. In between reference frames, the system transmits vectors to signify which areas in the frame have moved, and in what direction. Between the motion vectors, predictions are made to determine where the next movements will occur.

MPEG-2 on the other hand, combines high resolution and narrow bandwidth, and is designed to be used where image resolution and quality is critical. MPEG2 uses DCT for intraframe compression and "motion estimation" for frame to frame compression. Both processes operate on an 8 by 8 pixel area, called a block.

The MPEG algorithm is built around a discrete cosine transform (DCT) algorithm. This transform produces a two dimensional spectrum of the image, and allocates a priority to the contents of the spectral analysis, in order of importance to human perception of the image. The most important components are sent with high resolution, the lesser important components in low resolution, some not being sent at all. As this system intentionally deletes bits of information, it is known as a "lossy" compression method.

Specifically, the DCT method breaks the video signal up into blocks of 8 by 8 pixels. These blocks are then transferred from the spectral domain to the frequency domain by implementing a cosine transform, which is similar to one half of a fourier transform. In the frequency domain, elements that are not visible to the human eye can be removed.

The next step in compressing an image is "motion estimation". This is a system where an instruction can be sent, commanding a block of pixels to be moved from one position to another. This saves resending the entire block of pixels. So, once the signal blocks are transformed, motion estimation is performed, where the system tries to determine whether a block has either moved or changed.

The amount of compression that can be achieved by motion estimation depends upon the area of motion on which the search is performed. Depending upon the amount of computational power available, motion estimation can range from adjacent blocks of pixels, to the complete image.

Because the DCT technique is extremely intensive, a high level of computational activity is required, equating to high cost for the encoding equipment. This is one of the deficiencies of the MPEG scheme, but fortunately decompressing hardware is relatively simple.

The first service to utilise MPEG-2 for satellite transmission was "Direct TV", the US direct satellite broadcasting service, which commenced transmissions using MPEG-2 in April 1994. MPEG-2 is also designed to support the American Information Superhighway, and can be interfaced with the next generation communication/computer network, using ATM (asynchronous transfer mode), as well as HDTV.

At present, there are 14 international suppliers, all developing MPEG-2 decoders, some with enhanced functions. Amongst those functions are: on screen display (OSD) which will be used to display program guidance messages, a "3:2 pull down" function allowing users to covert 24 frames per second movies to 30 frames per second for TV, and a "pan/scan" function allowing users to convert an image with an aspect ratio of 4:3 into a 16:9 widescreen image.

In addition to the MPEG-2 LSI chipset, decoders will require up to 16Mbits of DRAM to store images of the highest quality (720 x 480/576 video). At the present rate per 1MB of DRAM, this makes the cost of a decoder somewhat expensive, although "stripped down" versions with less memory (and poorer resolution) could be used for the mass market. A version utilising 8MB of DRAM would provide "acceptable" images according to some chip manufacturers.

Industry commentators are hoping that the enormous world wide demand for MPEG-2 decoders will eventually bring DRAM prices down to realistic, affordable levels.

However, MPEG2 may not be the winner in the digital compression stakes. A proprietry solution, "Digicypher 2", designed by General Instruments, employs dual mode digital compression, allowing programmers to utilise either GI's proprietry system or MPEG2. Digicypher2 does not include the B frame or bi-directional interpolated frames that MPEG2 uses, saving significant cost per decoder. The B frames allow more data to be compressed, but at extra cost.

Consequently, a number of manufacturers have licensed Digicypher2, including LSI Logic and Motorola. IBM has announced its own MPEG2 chip, which can decode either MPEG1 or MPEG2, and Scientific Atlanta have also announced they will be supporting MPEG2.

In Australia, now defunct pay TV operator Australis Media (Galaxy) initially announced they would be using General Instruments' Digicypher 2 video compression system.

However, some months later, this decision was scrapped, and the company committed to several hundred thousand DVB compliant MPEG2 set top decoders from English manufacturer Pace.

Elsewhere in the Pacific, Hong Kong broadcaster TVB is using the Digicypher system to deliver programming to cable operators in Taiwan, whilst a group of broadcasters using the Panamsat PAS-2 satellite have adopted the Scientific

Atlanta MPEG 2 proprietry format, using their D9223/4 "PowerVu" decoders.

Due to the high cost of development, and the relatively small Australasian market, it is likely that the unit cost for video compression equipment will initially be high, around $1200.

DVB Compliant MPEG Decoders

In late 1995 there was an initial push by European broadcasters to produce a single, and universal standard for digital transmission (satellite or terrestrial) using the MPEG format. Prior to that time, a number of manufacturers, predominantly in the USA (General Instruments, Scientific Atlanta) had produced proprietory MPEG decoders for dedicated closed user systems.

Scientific Atlanta D9223 "PowerVu" IRD

It is not illogical to assume that if all MPEG decoders were compatible, rather than proprietory decoders, then the transition from analogue to digital transmission should proceed smoothly.

By early 1996, most European broadcasters had agreed to adopt "DVB compliant MPEG" as the digital standard of the future. The first manufacturer to produce a DVB compliant MPEG IRD was UK maker PACE, who produced their DGT-400 for Australis Media's Galaxy TV, the first Pay TV operator in Australia.

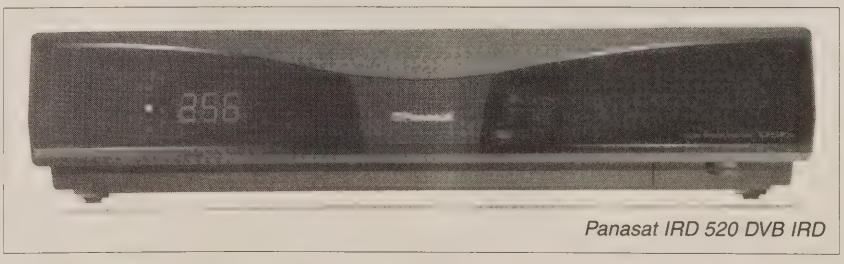
In 1996, Multichoice, a Pay TV operator in South Africa commenced MPEG operations using locally produced DVB Panasat decoders.

Both the Panasat 520 and the Pace DGT-400 can also be used on the 5-channel European bouquet, carried on Asiasat 2. This digital service has no "conditional access" restrictions.

Proprietry MPEG systems are not immediately compatible with DVB compliant decoders, and DVB compliant decoders offer significant advantages to the user over those earlier, non compatible models. All programmers using the DVB standard will have a common bit stream mapping system and a common access code processing system. This means that any programmer using DVB will be able to address any DVB compliant receiver, regardless of the source or brand. This will effectively end the monopoly held by Scientific Atlanta (for instance) who control the supply of IRDs for many of the FTA services carried on the Panamsat PAS-2 satellite in the Pacific.

Scientific Atlanta software engineers are striving to improve compatability of the D9223/4, so that it can also be used with DVB MPEG services operating without conditional access.

Theoretically, if all broadcasters cooperated, any DVB receiver could be used for any digital broadcast, once authorised by the broadcaster, offering the service.



Panasat IRD 520 DVB IRD

Conditional Access

Presently, the most prolific conditional access system is that designed by Dutch company IRDETO. Capable of processing MPEG-2 data at 54 Mb/s, Irdeto's Conditional Access Module (below) descrambles the MPEG-2/DVB data stream (and filters off ECM's and EMM's under the control of the smartcard).

All communication with the smartcard is via the CAM. As well as inputs and outputs for the scrambled and unscrambled MPEG-2 data, the CAM has serial bus connections to the smartcard and the Integrated Receiver Decoder (IRD).

The CAM was initially implemented as a PCMCIA-3 module that plugs into the IRD via a simple interface to the IRD circuitry. This approach has several advantages. It makes a universal IRD platform possible for all territories, therefore allowing economies of scale for manufacturing both IRD and CAM. Hence, technology upgrades can be simply undertaken by replacing the CAM in the field.

Normally a conditional access module (in addition to a subscriber smartcard) is required in conjunction with an MPEG receiver for subscription services.

However some services (the European Bouquet of five TV channels carried on Asiasat 2) require neither smartcard or CA module for reception of such FTA (free to air) services.

The reception of digital signals is somewhat more complicated than a simple analogue receiving system, and any errors in the received data can result in unacceptable breakdown of the picture into mosaic components or even complete freeze frame. To understand why this is so, a simplified explanation of the theory behind transmission of digital signals is necessary.

In the late 1940's, a US engineer, Mr Claude E Shannon produced an "Information Theory" pertaining to data transmission, that showed that the capacity of a digital channel is determined from the number of data bits per second that can be transmitted with an acceptably low bit error rate. The capacity of the channel is a function of the bandwidth and the available signal to noise ratio. This theory is of great use to communications engineers, as it provides a method of determining the achievable limits over a given communications link.

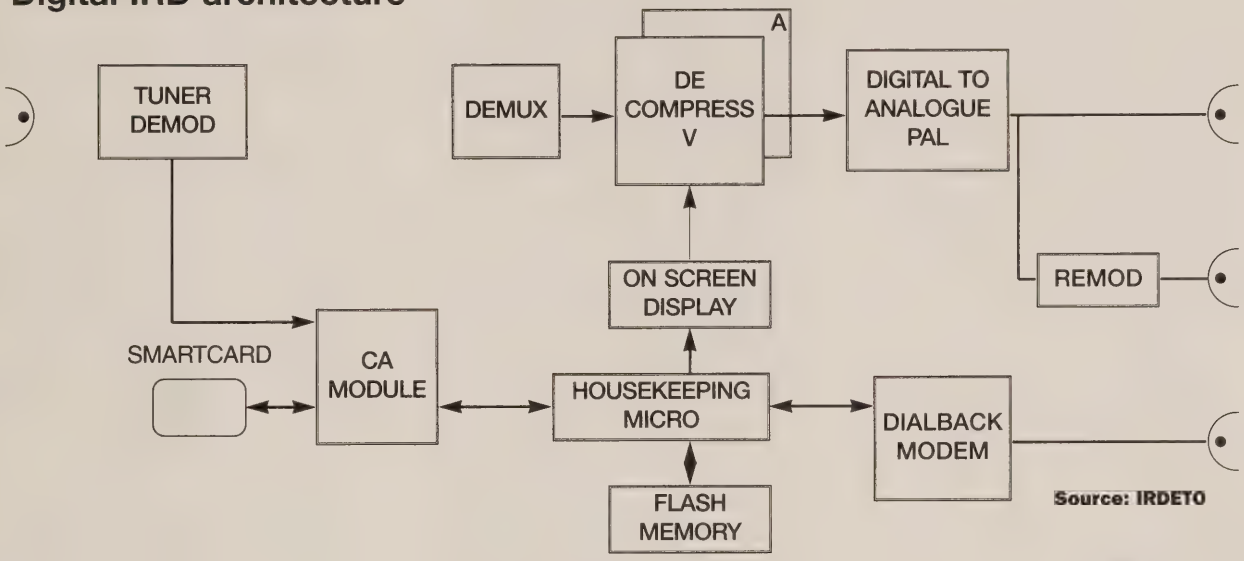
Conditional Access Module

In order to minimise the amount of data lost due to signal distortion over the transmission path, and through the non linear parts of the receiver, Forward Error Correction (FEC) is used to add extra bits of information to the data stream. These extra bits are added in a predictable way, so that the decoder can utilise them to assist in data recovery.

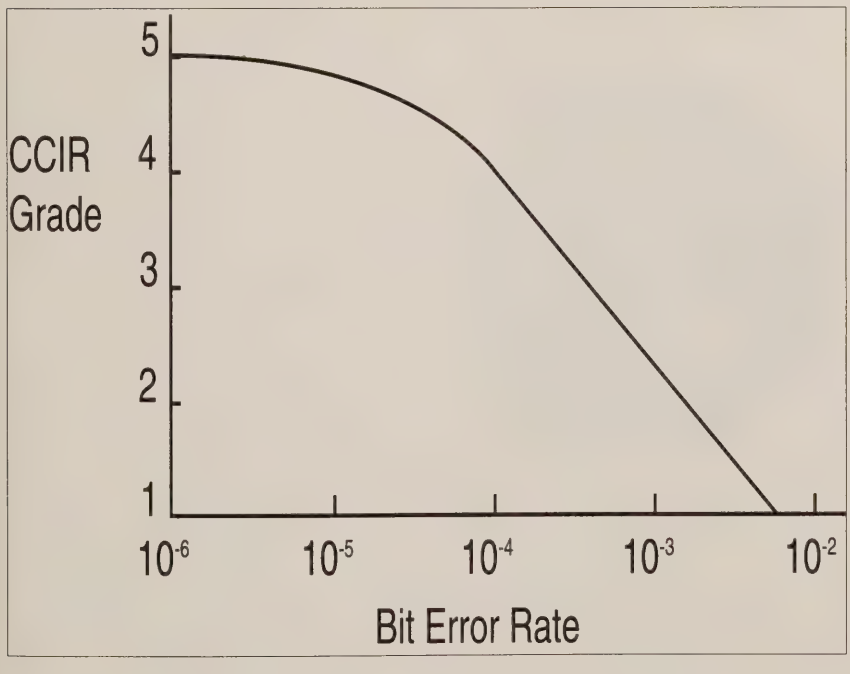
In digital systems, the equivalent to the Signal to Noise ratio, is En/No, defined as the energy per information bit, to noise density ratio. For every specific modulation and encoding system in use, there is a value of Eb/No which corresponds to the expected Bit Error Rate at the decoder. Subjective tests have shown that a BER of 10^{-6} or better is required for the equivalent of CCIR grade 5 video quality.

The graph on the following page shows the relationship between Bit Error Rate and video quality. Digital receiving systems are far less forgiving of low signal or poor cross polarisation, and particular care must be taken with these two aspects of a home satellite TV system.

Digital IRD architecture



Relationship between CCIR Grade & BER



CCIR Grades

Quality	Attributes	S/N
Excellent(5)	Noise free	46dB
Good(4)	Minimal Noise	42dB
Fair(3)	Noticable Noise	38dB
Poor(2)	Annoying Noise	33dB
Bad(1)	Very annoying	29dB

Setting up a Satellite Receiver System

Preparatory Work

There are many satellites visible from Australia, all with varying power levels and program content. In order to set up a satellite earth station that will provide satisfying results, it is important to carefully consider the available satellites and their suitability. This will determine the required dish size, and operating band.

At present, there are also government regulations in place, preventing overseas broadcasters offering Pay TV services direct to the Australian general public.

By convention, C band is used by international broadcasters, whilst K band is generally used for domestic satellite transmissions. Presently, there are few sources of K band signals, typically Optus B1 and B3 satellites, and occasional teleconferencing, carried on Panamsat's PAS-2 satellite.

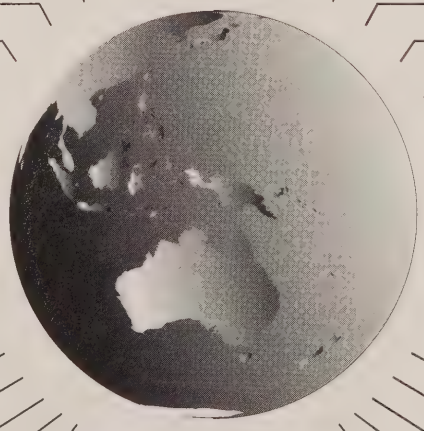
The Optus satellites form a national delivery system, carrying B-MAC/MPEG transmissions such as the ABC, SBS, and Queensland Television and Imparja.

These transmissions are designed as a consumer service for remote area viewers, and are collectively called HACBSS (Homestead and Community Broadcast Satellite Service).

In addition, the commercial networks use the Optus satellites to distribute regular programming, using an encryption system called E-PAL.

The third type of transmission on this satellite is known as the "interchange" service. This type of material is designed to be received by regional TV stations for terrestrial re-distribution. Such programming might comprise 30 second "promo" advertisements, entire programs destined for subsequent rebroadcast, or news feeds from portable uplink stations or overseas affiliates.

SATELLITES VISIBLE FROM AUSTRALIA



53°E	Gorizont 32
57°E	Intelsat 703
60°E	Intelsat 604
62°E	Intelsat 602
64°E	Intelsat 804
66°E	Intelsat 704
68.5°E	Panamsat 4/7
72°E	Intelsat 505
76.5°E	Apstar 2R
78.5°E	Thaicom 3
80°E	Gorizont 24
83°E	Intelsat APR-1(98)
90°E	Gorizont 28
85°E	Raduga 30
91.5°E	Meast 1
93.5°E	Insat 2B/2C
96.5°E	Gorizont 27
100.5°E	Asiasat 2
103°E	Gorizont 25
105°E	Asiasat 3
107.7°E	Indostar 1
108°E	Palapa B2R
113°E	Palapa C2
118°E	Palapa B4
122°E	Asiasat G
128°E	JCSat 3
134°E	Apstar 1A
138°E	Apstar 1
139°E	Orion 3
140°E	Gorizont 22
145°E	Gorizont 21
146°E	Agila 2
148°E	Meast 2
150°E	JCSat 4
150.5°E	Palapa C1
152°E	Optus A3
156°E	Optus B3
158°E	Avsat
160°E	Optus B1
Agila 3 1999 161°E	Agila 1
164°E	Optus A2
mid 1998 166°E	Panamsat 8
169°E	Panamsat 2
174°E	Intelsat 802
177°E	Intelsat 702
180°E	Intelsat 701
183°E	Intelsat 513
187.5°E	TDRSS 5

C band signals can come from a number of satellites, ranging from the "Gorizont" class spacecraft carrying Russian broadcasts, Asiasat 2 carrying European and Chinese language broadcasts,the Palapa C2 satellite carrying Indonesian and Malaysian programming, and Intelsat and Panamsat satellites carrying programming from the USA.

In the case of Optus K band interchange satellite reception, a suitable dish (1.6m in diameter), LNB (low noise block converter), and feedhorn are required. For C band reception, a good general purpose size dish is 3m. This will provide reception from most of the available international satellites. There are however, some instances where either a smaller or larger dish is recommended, for dedicated single satellite reception.

Footprints for specific satellites should be consulted prior to deciding dish sizes.

Pointing the Dish

For every location in Australia, there is a different set of "pointing co-ordinates" required to point a dish at a specific satellite. Dish pointing co-ordinates can be calculated using a number of commercial software programs, and most equipment vendors will also calculate these on request, for any location in Australia.

Some computer programs have the ability to print pointing co-ordinates between latitude and longitude limits, simplifying the job of an installer. It is easier to carry a few sheets of paper, than a computer!

Most programs require the satellite longitude, the site latitude and longitude, as well as magnetic variation to perform this calculation, producing a magnetic bearing, a true bearing and the angle of elevation.

Figure 27 shows general "look angles" for the Optus B1 satellite across Australia.

Often latitude, longitude, and magnetic variation can be obtained from the local airport. If this source is unavailable, most pilot supply outlets carry maps known as WAC (world aeronautical charts) charts, which show these details. The magnetic variation for the earth station site is important if a compass is to be used to help align the dish.

Another type of navigational map, called an "ONC" (overseas navigation chart) can be used. This type of map is available for virtually any part of the (populated) world, and also shows magnetic variation. ONCs cover a larger area than WACs, but provide less detail.

So, having decided on a satellite, assembled the necessary system components, and calculated the pointing co-ordinates (azimuth, and elevation), the dish must be pointed in the correct direction. The dish should have a clear view of the appropriate part of the sky, unobstructed by buildings or trees.

Where reception of multiple satellites is desired, the dish must be sited so that it has a clear view from west to east.

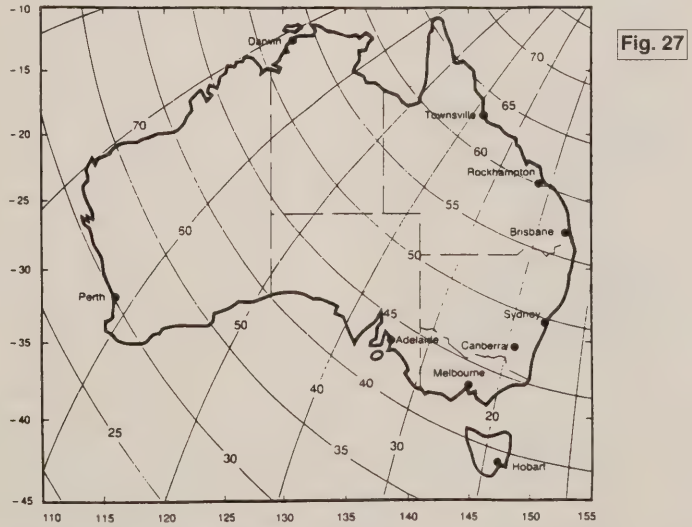
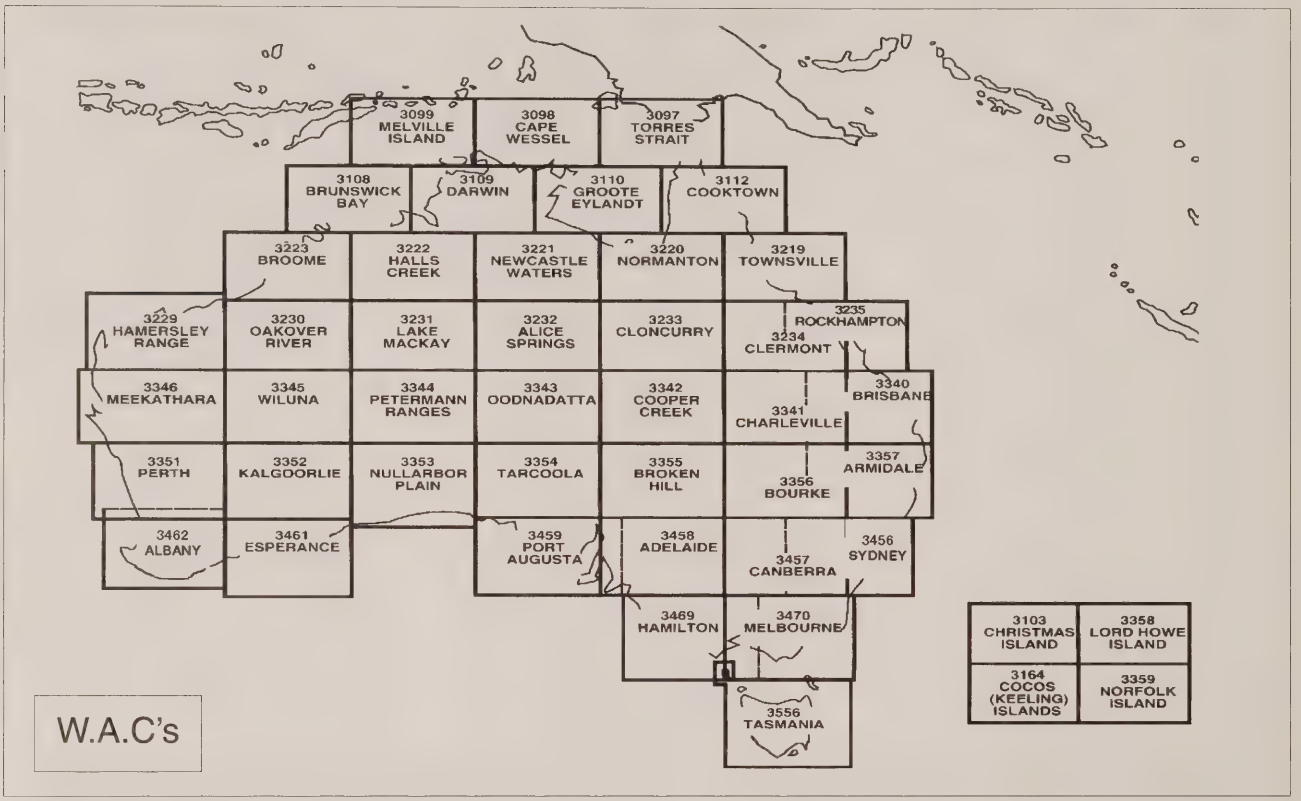
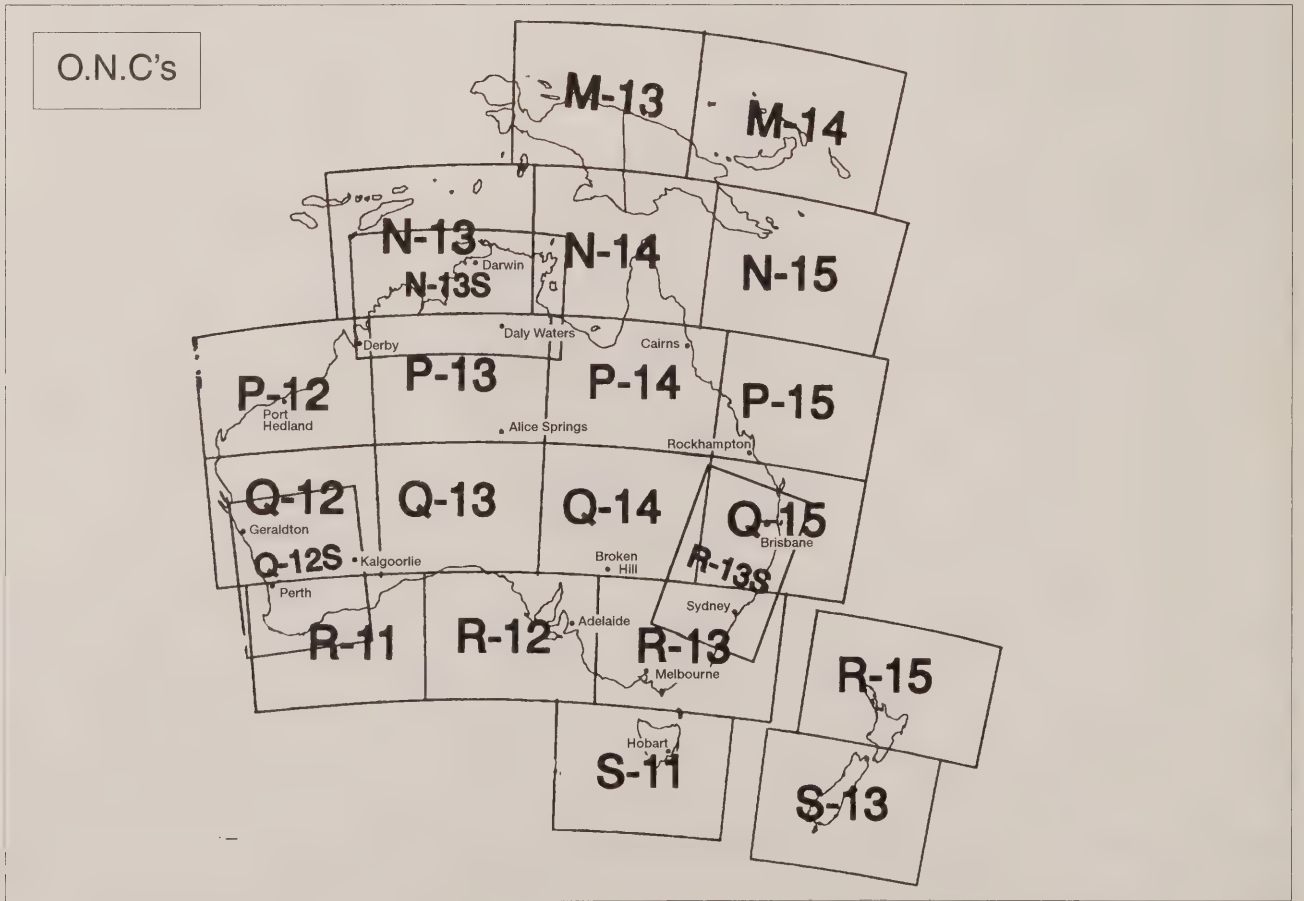


Fig. 27

Azimuth & Elevation Look Angles (Degrees) to Satellite at Orbital Location 160° Longitude


3099 MELVILLE ISLAND
3098 CAPE WESSEL
3097 TORRES STRAIT
3108 BRUNSWICK BAY
3109 DARWIN
3110 GROOTE EYLANDT
3112 COOKTOWN
3223 BROOME
3222 HALLS CREEK
3221 NEWCASTLE WATERS
3220 NORMANTON
3219 TOWNSVILLE
3229 HAMERSLEY RANGE
3230 OAKOVER RIVER
3231 LAKE MACKAY
3232 ALICE SPRINGS
3233 CLONCURRY
3235 ROCKHAMPTON
3234 CLERMONT
3346 MEEKATHARA
3345 WILUNA
3344 PETERMANN RANGES
3343 OODNADATTA
3342 COOPER CREEK
3340 BRISBANE
3341 CHARLEVILLE
3351 PERTH
3352 KALGOORLIE
3353 NULLARBOR PLAIN
3354 TARCOOLA
3355 BROKEN HILL
3357 ARMIDALE
3356 BOURKE
3462 ALBANY
3461 ESPERANCE
3459 PORT AUGUSTA
3458 ADELAIDE
3457 CANBERRA
3456 SYDNEY
3469 HAMILTON
3470 MELBOURNE
3556 TASMANIA
3103 CHRISTMAS ISLAND
3358 LORD HOWE ISLAND
3164 COCOS (KEELING) ISLANDS
3359 NORFOLK ISLAND
W.A.C's


O.N.C's
M-13
M-14
N-13
N-13S
N-14
N-15
Darwin
Derby
Daly Waters
Cairns
P-12
P-13
P-14
P-15
Port Hedland
Alice Springs
Rockhampton
Q-12
Q-13
Q-14
Q-15
Geraldton
Brisbane
Q-12S
Kalgoorlie
Broken Hill
R-13S
Perth
Sydney
R-11
R-12
Adelaide
R-13
R-15
Melbourne
Hobart
S-11
S-13

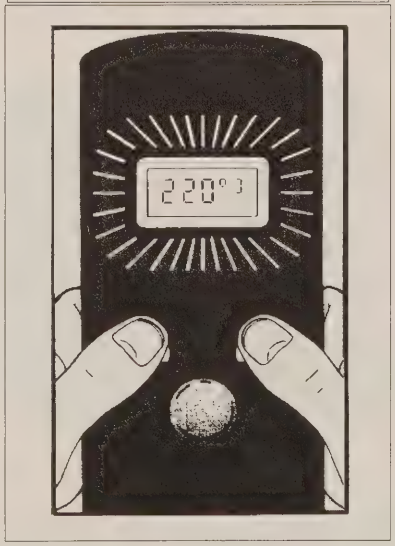
Siting the Dish

It is important that the satellite dish has an unobstructed view of all desired satellites. The dish will not operate at peak efficiency if the signal is even partially blocked by obstructions such as trees buildings etc. A visual inspection is always necessary to ensure a clear path. One device especially useful for this purpose is the combined inclinometer and compass. Using this device, it is possible to read elevation, azimuth and also simultaneously "eyeball" the path, to ensure it is clear.

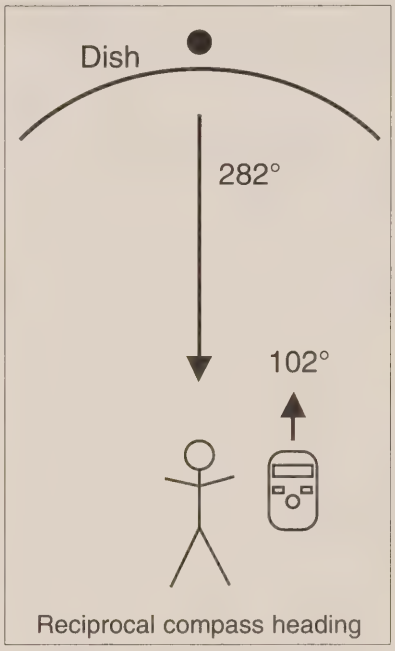
Compass/Inclinometer

Another useful item is the hand held digital flux gate compass. This unit allows the user to point and memorise azimuth headings. No matter what the type of compass, extreme care should be taken to avoid the effects of residual magnetism caused by the close proximity of magnetic metals, and the resultant errors caused. Sources of residual magnetism include wristwatches, eye glasses, cellular phones, pocket pagers, and of course steel dish mounts !!

Digital fluxgate compass



Where it is not possible to physically stand in alignment and close proximity to a dish, the reciprocal compass heading can be used. By standing well in front of a dish (and away from all metal likely to cause compass errors), and checking the azimuth to the calculated value minus 180°, a more reliable reading can be obtained.



Reciprocal compass heading

The Site Survey

Unfortunately, and especially in our crowded cities, there are many sources of microwave energy that can interfere with satellite TV reception. Also, where a dish is to be mounted on a roof, (where buildings cannot shield microwave interference) there is an increased risk of such interference.

It is hence prudent in many instances, to carry out a site survey. This can be as simple as connecting an LNB to a feedhorn and receiver, and whilst watching the TV screen, sweeping the LNB across the sky in the general direction of the satellite. Where the satellite channel frequency is known, the receiver should be tuned to that frequency. Where many channels are to be received, this test should be repeated for every frequency.

If no interference is detected using this method, there is a good chance none will be encountered on a satellite receiving system. The dish adds directivity, and the feedhorn when fitted adds polarity rejection, both of which will reduced terrestrial interference or "TI" as it is known.

For commercial installations, it is always wise to use a small test dish, fitted with LNB and feedhorn (set to the correct polarisation). This combination should be fed, via a power inserter, to a spectrum analyser, where the proposed satellite IF can be monitored, if necessary with a chart recorder for 24 hours. This is the only sure way to predict the level of interference prior to dish installation.

Troublesome Sites

Any site located near an airport which operates navigational aids such as radar, deserves close scrutiny prior to considering the installation of a satellite dish. Sites located directly in line with, or under aircraft flight paths can be adversely affected by airborne radar altimeters and weather radar. Check these sites carefully using a small dish prior to installation.

Likewise, it is often prudent to check sites located near microwave dish towers for interference. Although decreasing, there are still a number of 4GHz links along the East and West coasts, and along regional communications routes throughout Australia. As these microwave links operate at similar frequencies to those used for C band satellite downlinks, they can be a source of interference which can prevent the reception of all satellite TV signals.

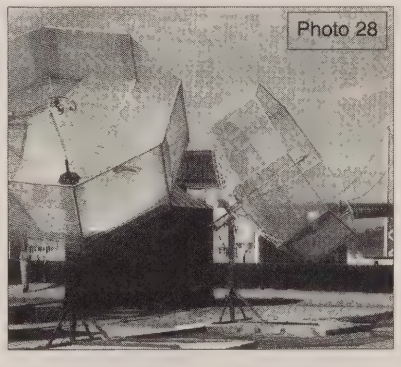
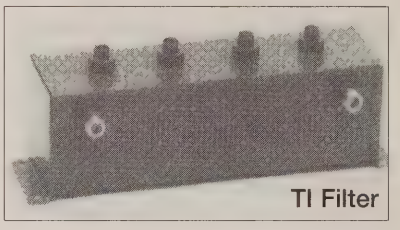


Photo 28

One possible solution which can be used to minimise terrestrial interference is the dish shroud. Photo 28 shows shrouded dishes on a crowded rooftop. The mesh shroud acts as a shield against TI occurring abeam, or at right angles to the dish. In practice, a shroud is used to advantage in most instances, unless the source of TI is directly inline with the azimuth of the dish. In such cases relocating the dish so that it is shielded by buildings, may have a more positive effect.

Where TI occurs on a single frequency within the satellite band, a microwave notch filter can also be used. Photo below shows such a filter.


TI Filter

Local Council Regulations

There is an increasing number of local councils requiring that "council permission" be given to private individuals prior to dish installation. In rural areas, this is normally no problem, some councils requiring only a sketch from the applicant showing the location of the dish relative to buildings, boundaries etc.

In city areas, this requirement is becoming more of a problem to private individuals. The requirement for an official submission seems to hinge on whether or not a satellite dish is classified as a "structure". A ground mounted dish could hardly be classified as a structure.

In some cases a development or building application will be necessary. Some councils have stated they will not allow private individuals to install dishes, and can issue a legally binding

demolition order for dishes installed without approval.

There are two matters with which councils concern themselves, when it comes to dish installations:

(A) does the installation comply with good engineering standards ie is there any public liability? and

(B) does the installation have any visible impact on the local landscape?

Both these matters can generally be successfully dealt with, by using a structurally certified dish mount, and often by using visual screening such as shadecloth or lattice to hide the dish.

Whether an individual decides to seek council approval or not, it is wise to consider both matters prior to dish installation.

If a problem is encountered with a local council after dish installation, a personal approach should be made to the highest ranking official, who will no doubt be acutely aware of the value of favourable votes at the next local election!

Dish Alignment

There are 4 critical parameters which must be accurately set, in order to align the dish with the desired satellite. The dish elevation above the horizon, the azimuth, focal point and LNB polarity.

For Az/El mounted dishes, the easiest way to correctly point the dish, is to set the elevation first. This can be done with an inclinometer or anglemeter, placed on the back of the reflector, or on the

Antenna Pointing Program

```
10 CLS:PRINT "GEOSTATIONARY SATELLITE BEARINGS FOR SOUTHERN HEMISPHERE"
20 PRINT "--------------------------------------------------------------------------------":PRINT
30 INPUT "ENTER YOUR LATITUDE IN DEGREES AND DECIMAL DEGREES (E.G. 30.855)";A
40 INPUT "ENTER YOUR LONGITUDE IN DEGREES AND DECIMAL DEGREES (E.G. 152.922)";Q
50 INPUT "ENTER THE SATELLITE LONGITUDE IN DEGREES EAST";Y
60 INPUT "MAGNETIC DEVIATION FOR DISH LOCATION (0 IF NOT KNOWN)";MD
70 IF Y>Q THEN GOTO 110
80 IF Y<Q THEN GOTO 90
90 B=Q-Y
100 GOTO 120
110 B=Y-Q
120 C=A *.0174533
130 D=B *.0174533
140 E=SIN(C)
150 F=TAN(D)
160 H=3.1416+ATN((F/E))
170 AZ=H *180/3.1416-180
180 IF Y>Q THEN GOTO 220
190 IF Y<Q THEN GOTO 200
200 AS=360-AZ
210 GOTO 230
220 AS=AZ
230 J=(COS(C) *COS(D))
240 CA=-ATN(J/SQR(-J *J+1))+1.5708
250 CB=+CA *180/3.1416
260 R=3957
270 K=22245
280 RA=SQR((R *R)+(R+K) *(R+K)-2 *R *(R+K) * COS(CA))
290 T=((RA *RA+(R *R)-((R+K) *(R+K)))/(2 *RA *R))
300 TL=-ATN(T/SQR(-T *T+1))+1.5708
310 EL=(TL *180/3.1416)-90
320 RB=RA *1.609344
330 PRINT:PRINT "--------------------------------------------------------------------------------"
340 IF EL<=5 THEN GOTO 440
350 PRINT "AZIMUTH  = ";AS;" DEGREES FROM  TRUE NORTH"
360 IF MD=0 THEN GOTO 380
370 PRINT "AZIMUTH  = ";(AS+(MD));"DEGREES FROM MAGNETIC NORTH"
380 PRINT "ELEVATION  = ";EL;"DEGREES"
390 PRINT "RANGE  = ";RB;"KILOMETRES"
400 PRINT:PRINT:PRINT "PRESS ANY KEY TO CONTINUE OR E TO END"
410 A$=""
420 A$=INKEY$: IF A$="" THEN GOTO 420
430 IF (A$="E") OR (A$="e") THEN GOTO 460 ELSE GOTO 10
440 PRINT "SATELLITE TOO LOW... ELEVATION IS";EL;"DEGREES"
450 GOTO 400
460 END
```

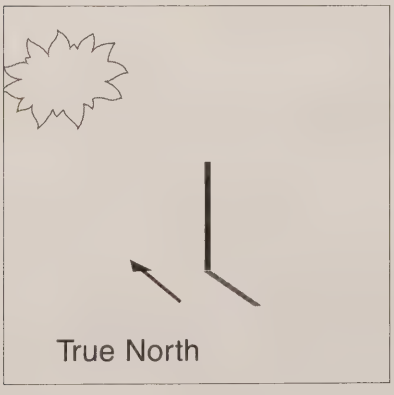
Example Run of Program

```
ENTER YOUR LATITUDE IN DEGREES AND DECIMAL DEGREES (E.G. 30.855) 30.855
ENTER YOUR LONGITUDE IN DEGREES AND DECIMAL DEGREES (E.G. 152.922) 152.922
ENTER SATELLITE LONGITUDE IN DEGREES EAST 160
MAGNETIC DEVIATION FOR DISH LOCATION (0 IF NOT KNOWN) 0
--------------------------------------------------------------------------------
AZIMUTH    = 13.60957 DEGREES FROM TRUE NORTH
ELEVATION  = 53.23546 DEGREES
RANGE      = 36893.85 KILOMETRES
```

rim of the dish. There is a detailed procedure for the correct set up of polar mounted dishes. This procedure primarily ensures that the mount correctly tracks the geostationary arc. Locating true north is the most critical aspect of setting up a polar mount.

Finding true north is easiest and most accurately done mathematically, by determining the time for sunrise or "first light", and sunset or "last light", for the day on which the mount is to be aligned. This can normally be obtained from astronomical observatory, or from the meteorological office of an airport. Some time correction is necessary depending upon geographic location, and these corrections are also available from the same sources.

The mid point of the day, can be calculated by subtracting the time of sunrise from that of sunset, and halving that interval. At this precise time, the shadow cast by a vertical rod corresponds to True North. The shadow can be marked on the ground or rooftop for reference.



If the chosen day is cloudy, an alternative method can be used. The reflector and mount must be aligned so that they are both pointing in exactly the same direction. The elevation for the chosen satellite can be determined from dish pointing software, and the dish elevation set to that value.

The satellite signal should be acquired by rotating the dish and mount locked together, on the pole. When the signal is optimised, the position of the mount should be marked on the pole, as a reference.

The calculated value of true azimuth for the acquired satellite should be mathematically compared to True North (zero derees). If the difference is a number between 0 and 180 degrees, True North lies to the west of the dish position. If the difference lies between 180 and 360 degrees, True North lies to the east of the dish position.

In order to rotate the dish mount to the correct position for True North, a mathematical relationship must be derived, linking degrees of azimuth to distance around the pole, ie a "degrees per millimetre" ratio. This is easily achieved when using 4 1/2 inch steam pipe (a commonly used size) because the circumference is 360mm, ie 1mm per degree of azimuth. For 3 1/2 inch nominal diameter steam pipe, this ratio is 0.77mm per degree of azimuth. Other ratios can easily be calculated.

By multiplying the ratio by the number of degrees of azimuth adjustment required, a distance around the pole can be derived. As the direction of rotation has been previously calculated realigning the locked dish and mount by the calculated distance, is relatively simple and alignment with True North can be achieved.

The value of dish elevation required at True North to ensure correct tracking of the polar arc is derived by subtracting the site latitude from 90 degrees. in the case of Sydney, latitude 34 degrees, this equates to 56 degrees of elevation. This adjustment must be carried out with the declination adjustment set to zero, ie reflector is parallel with the mount. Figure 17 shows use of an inclinometer.

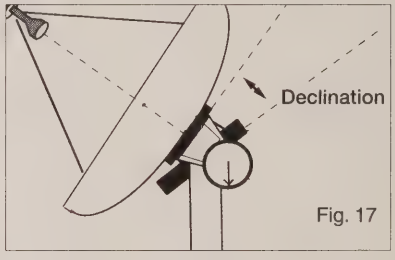


Fig. 17

The final polar mount adjustment is called declination. This is the angle between the reflector elevation and that of the mount. The value of declination varies according to site latitude, and introduces tracking compensation for the apparent flattening of the geostationary arc when viewed from sites with extreme southerly latitude. The declination is set so that (in the southern hemisphere), the reflector is tilted forward slightly from the mount.

Declination ensures the dish tracks in an arc, rather than a straight line (the horizon is curved, not flat!)

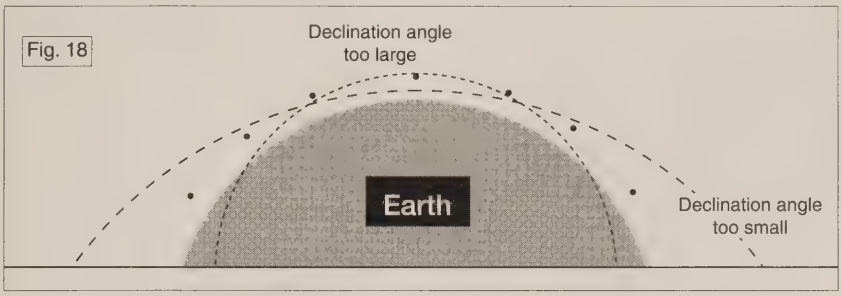
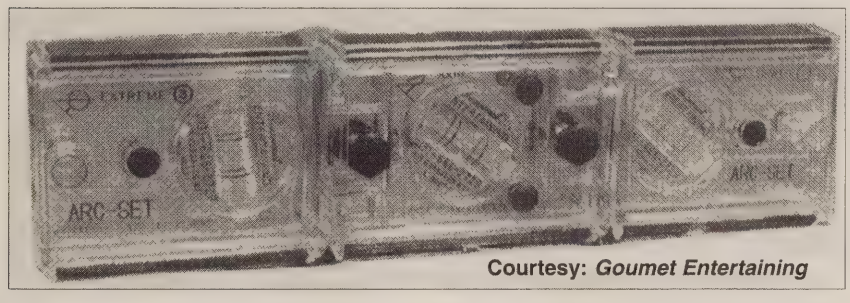


Figure 18 shows the effect of incorrect declination adjustment.

For those who find this method cumbersome, there exists a simple instrument that can be used to align a polar mount. Called an "Arc Set" this device comprises an assembly of three bubble levels.



Courtesy: *Goumet Entertaining*

These 3 levels allow an installer to correctly set dish mount zenith, declination and elevation, based on site data.

By using dish pointing coordinates derived from a pointing program, the dish azimuth can be aligned to roughly the correct position.

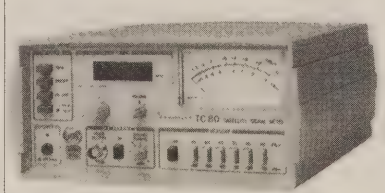
By tuning the receiver to the correct IF frequency, and monitoring the receiver output whilst adjusting the dish azimuth, it is generally possible to align a dish for single satellite reception.

Finally the polarity of the LNB must be set. In practice, this can be done after a signal is acquired, and the LNB is simply rotated for best reception of the desired transponder, corresponding to maximum rejection of the opposite polarity. This is the same whether a motorised feedhorn is used, or a manual type.

By far the easiest way to set up a dish, is to have all the equipment ie receiver and TV set or video monitor, at the dish. This way signals can be directly observed as the dish is moved. This is far preferable to any other remote monitoring system.

For most accurate results a satellite meter should be used. A unit for professional installers can cost up to $2000. (Fig.29) Some meters even incorporate a spectrum analyser, particularly useful when aligning a satellite system to receive digital signals.

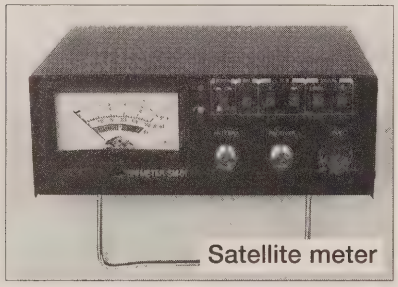
Fig.29



DECLINATION CHART	
LATITUDE	DECLINATION
0	0
1	0.16
2	0.31
3	0.47
4	0.62
5	0.77
6	0.93
7	1.08
8	1.24
9	1.39
10	1.54
11	1.69
12	1.84
13	2.00
14	2.14
15	2.29
16	2.44
17	2.59
18	2.74
19	2.88
20	3.03
21	3.17
22	3.31
23	3.45
24	3.59
25	3.73
26	3.87
27	4.00
28	4.14
29	4.27
30	4.40
31	4.53
32	4.66
33	4.78
34	4.91
35	5.03
36	5.15
37	5.27
38	5.39
39	5.51
40	5.62
41	5.74
42	5.85
43	5.96
44	6.06
45	6.17
46	6.27
47	6.37
48	6.47
49	6.57
50	6.66

For the DIY enthusiast a "satellite finder" is available for less than $100. Whilst not a scientific instrument, this relative power meter can be used to peak dish alignment, focal length and LNB polarity.

Located mid range (for about $400) is a Nicad battery powered satellite meter which is also capable of simple DC voltage and current diagnostics. The meter can indicate what DC voltage is being fed up the coaxial cable by the receiver and can measure the total LNB power from 900-2000 MHz being fed into the receiver.



After first peaking dish elevation, azimuth and focal length, LNB polarity should be optimised. This is best done by adjusting the LNB position for the minimum level of signals of the opposite polarity.

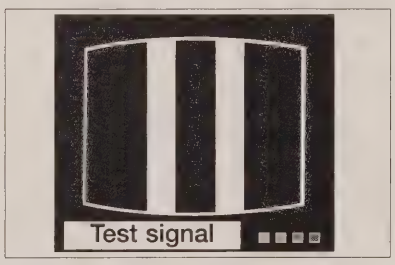
For a single polarity LNB (where the DC feed voltage is 18v) this means rotating the LNB for minimum meter response. For a dual polarity LNB this means rotating the LNB for minimum meter response when the DC voltage is switched to the receiving probe for signals opposite in polarity to those required ie as convention dictates 14v for vertically polarised signals, the minimum meter response is achieved when 18v is applied to the LNB. This procedure ensures maximum cross polarisation isolation.

The connection between the satellite receiving dish, LNB and feedhorn, which are all located outside, and the receiver is made via a length of RG-6/U coaxial cable. This cable carries DC voltage (18 volts maximum) to the LNB in one direction, and signal from the LNB to the receiver, in the other direction.

Even when the dish is not pointed at a satellite, a certain amount of noise or "snow" can be observed on the screen of the video monitor or TV set being used. Disconnecting the cable at the back of the satellite receiver, and noting the corresponding drop in "snow" on the screen is a simple method of verifying the integrity of the cable. If a drop in the noise level is observed, this means the cable and the LNB are working correctly.

Provided the receiver is tuned to an operational satellite channel, acquisition of a signal is simply a matter of pointing the dish correctly.

Most modern satellite receivers have an RF test signal which can be switched on to verify correct TV channel tuning.



Inclined Orbit Satellites

Somewhat more of a challenge is the set up of a dish to receive signals from a satellite in an inclined orbit. Some ageing satellites, kept in orbit due to the backlog of launch bookings for new satellites, have been deliberately placed into an inclined orbit, to prolong their useful life.

In this situation, a certain amount of station keeping tolerance is acceptable to ground stations. By accepting the resultant effects of gravitational pull of the Sun and the Moon, the radiation force of sunlight, and the pull of the gravitational field of earth, and allowing the satellite to drift within a target "box" or window in space, a significant amount of station keeping fuel can be conserved.

There does exist a patented manoeuvre, called the "Comsat Manoeuvre", which cleverly conserves station keeping fuel. Part of the patent reads. "a conventional satellite uses an average of 37 pounds of station keeping fuel for each year of design life, approximately 34 pounds of fuel is used for North/South correction, whilst only 2 pounds is used for East/West correction, and one pound for attitude control". So it is obvious that any kind of manoeuvre that can minimise the amount of fuel used in North/South station keeping can prolong the life of the satellite.

Generally, satellites have been placed in an inclined orbit deliberately, either due to low station keeping fuel reserves, or in the case of early Russian satellites, because such an orbit takes the satellite over populated landmasses, rather than ocean for most of a 24 hour period.

Whatever the reason, acquiring, then tracking an inclined orbit satellite requires more skill than a fixed satellite.

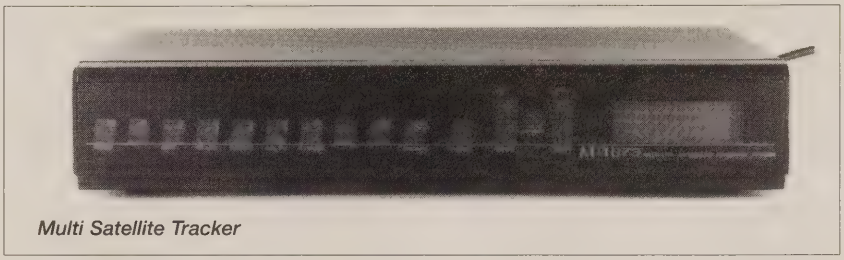
If 24 hour reception of such a satellite is required, the dish mount must be fitted with

bearings or bushes in both axes, to ensure that the constant movement of the mount does not cause it to wear. A standard polar mount without bushes (particularly in the elevation axis) is not suitable. Typically, the elevation pivot is formed by a threaded bolt, which acts like a file during tracking operation, quickly wearing out one side of the mount !! A satellite tracker must also be incorporated into the receiving system.

The most logical way to predict the azimuth and elevation of an inclined orbit satellite, is to obtain pre-calculated co-ordinates. Commercial software programs like "Logsat" allow users access to internet sites to download updated Keplerian elements used by the software program to calculate satellite orbital positions.

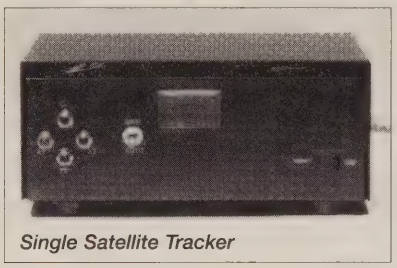
Because, the orbit of an inclined satellite is controlled by an earth station, the orbital or Keplerian elements are available from NORAD, the US government agency, charged with monitoring all objects in space. Most satellite oriented Internet sites keep these elements on file, and constantly updated.

By "plugging in" these orbital elements into a computer tracking program, a table can be produced showing where an inclined orbit satellite is, at any time of the day or night. This table also shows the time at which the satellite will be located with zero degrees variance from the nominal orbital location.



Multi Satellite Tracker

Once the satellite is located and a signal acquired, the system tracker must be installed. Various trackers are available, from the simplest single satellite tracker, to more complex trackers incorporating predictive memory, and complex microprocessor circuitry with sufficient memory for many satellites.



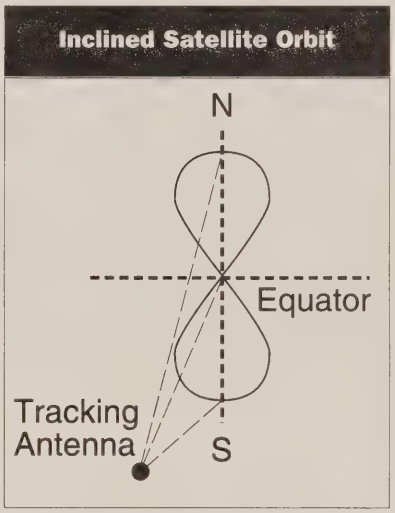
Single Satellite Tracker

The single satellite tracker uses a fixed time interval to sample received satellite signal strength. The unit has an inbuilt tuner, set to the desired input frequency. Every fifteen minutes or so, the internal micro-processor drives each motor (one per axis) in each direction for 950 mS or so.

As the dish moves, the received signal strength will either increase or decrease, instructing the motor control circuit to either continue in the same direction or to reverse the motor direction.

For this system to work well, the dish must be well balanced so that travel in an upward direction for a fixed time interval, equals distance travelled in a downward direction for the same time interval.

Dish mounts should employ bearings or at least bushes in the elevation axis, and often must use a counterweight for correct balance.



The multi satellite tracker requires an external AGC voltage, and uses a PWM (pulse width modulation) motor drive circuit to ensure minute changes in actuator position, whilst peaking the dish. This system has the advantage of rarely degrading the received signal to any large extent during autotrack operations.

Multiple Satellite Systems

When proposing to install a multiple satellite receiving system, attention should be paid to the weakest satellite available, and what dish size is required for good reception of that satellite.

The location of the dish must be such that is has a clear view from the (calculated) most western to most eastern azimuth. Generally, this means a clear view from the western horizon to the east. As there is no satellite having a footprint over Australia located further east than 187.5 degrees east longitude (Nasa's TDRSS satellite), this is the figure to use when calculating the most eastern azimuth.

For dishes located on the east coast, the most western satellite visible is the Apstar 2R satellite located at 76.5 degrees east. The required elevation for this satellite is around 5 degrees. Dishes located further west will have a marginally higher "look" angle.

Receiving systems for multiple satellites, where satellites are located low on the horizon, should use a horizon to horizon mount, or a motorised Az/El mount instead of a standard polar mount. Such a system should also use a dish controller, capable of controlling actuators in both axes. Some receivers have this capability built in such as the Dynasat 300 receiver/positioner shown below.

Having considered the appropriate dish size, and location, some regard should be given to the polarisation used by all available satellite transponders.

For C band satellites, a feedhorn capable of being remotely adjusted for linear (vertical and horizontal) as well as circular (RHCP and LHCP) should be chosen. Photo below shows a multipolarity feedhorn.

In our part of the world, K band signals use linear polarisation.

Multiple polarity feedhorn

As we have many available satellites utilising linear polarisation, some regard to polarisation offset is necessary. If the receiving site was located directly below the satellite, there would be no polarisation offset. Traditionally, the vertical polarisation reference is assumed to be perpendicular to the equator. The angular difference between the polarisation plane of the satellite, and that of the receive site, varies with site latitude and the longitudinal difference between the satellite and site. However, many broadcasters follow the practice of tilting the satellite polarisation (particularly with spot beams), so that the polarisation plane at the centre of the footprint coincides with the local vertical reference.

This is why it is important to use a feedhorn capable of polarisation adjustment, even for reception of satellites employing linear polarisation.

If dual band reception is required, consideration should be given to the difficulty experienced in pointing a large dish (with narrow beamwidth) at a K band source, and to the inefficiency of mesh dishes at K band, which typically drops to around thirty percent. Also, there are some feed inefficiencies which will be introduced when using a dual band feedhorn.

Considering the limited number of sources of K band signals available, it is far preferrable to use a second, dedicated dish for K band reception. In such an instance, a dual input receiver is required.

Mounting the Dish

Dishes can be mounted in a variety of ways, depending upon the individual site. The easiest and most commonly used system, is to mount the dish directly on to a pole cemented into the ground. The pole should be kept as low as possible, to make

maintenance or future upgrades relatively convenient. Mounting a 1.6m dish on top of a 6m length of pipe, makes maintenance impossible, and creates an eyesore. Such situations are to be avoided at all costs.

Dishes can be wall mounted, providing the mount and the wall have sufficient strength and load bearing capacity. Wall mounts should be certified by a structural engineer for the category corresponding to predicted wind velocity for the site. Maximum bonding to brick and block walls is achieved using chemical anchors.

For wall mounted dishes below 2.3 metres in diameter, 12mm chemical anchors should be used, whilst a 3m wall mount requires 20mm anchors. A 3.7m wall mount requires 30 mm anchors.

Photo shows wall mounted dish

International Video Standards

It is common knowledge that most countries around the world use either the NTSC, PAL or SECAM video standard. On international satellites it is not uncommon for a combination of standards to be used. In the Pacific, Intelsat 701 and Panamsat 2 are typical examples.

The differences between the 3 major video systems are not as clear cut as they might initially seem, and it is true to say that all systems are a compromise between complexity and monochrome compatability. All TV receivers require a field timing reference signal, and initially this reference was derived from the AC mains.

As there are two main power frequencies in use around the world, the three major systems are based on either 25 frames per second (50Hz), or 30 frames per second (60Hz). This is the biggest incompatability between standards, and the most difficult to resolve.

The majority of 60Hz based countries use a system called NTSC, developed in the USA in 1953 by the National Television Standards Committee. Because of problems of hue variance (caused by changes in the colour sub carrier phase) the NTSC system is sometimes referred to as the Never Twice the Same Colour system. Because NTSC uses a higher frame rate (30 frames per second) than PAL, it has reduced video flicker, however as the gamma ratio for NTSC is set to 2.2, NTSC cannot produce the high level of contrast achievable with the PAL system.

A modification of the NTSC system, devised by German engineers to overcome the hue problem, called the PAL (phase alternating line) system was introduced in most 50Hz countries. Known by some as the Pictures At Last system, the main difference between NTSC and PAL is the colour subcarrier phase reversal on each alternate line. The frequency of the colour subcarrier is also different to that used in the NTSC system. The main advantages of the PAL system is the greater picture detail (625 scan lines compared with 525 for NTSC), a higher gamma ratio (2.8) for greater picture contrast, stable hue due to the reversal of the subcarrier phase on alternate lines (any phase error on the subsequent line), and wider luminance signal bandwidth due to the higher subcarrier frequency of 4.43MHz. PAL is the most widely adopted system in the 50Hz countries.

The French designed a system of their own known as SECAM (SEquential Couleur Avec Memoire). Known by some as System Essentially Contrary to American Method, the SECAM system is said to have been designed to protect the French domestic manufacturing industry. The SECAM system has similar advantages over NTSC, but has the primary disadvantage that the FM subcarrier used causes patterning effects even on non coloured objects. Also, there are a wide number of SECAM variants which are incompatible. French SECAM uses an FM subcarrier, whilst Middle Eastern SECAM uses an AM subcarrier.

Australia	PAL
Brunei	PAL
Burma	NTSC
China	PAL
Fiji	PAL
France	SECAM
Germany	PAL
Hawaii	NTSC
Hong Kong	PAL
India	PAL
Indonesia	PAL
Italy	PAL
Japan	NTSC
Korea(N)	SECAM
Korea(S)	NTSC
Malaysia	PAL
Micronesia	NTSC
New Zealand	PAL
Papua New Guniea	PAL
Phillippines	NTSC
Portugal	PAL
Russia	SECAM
Samoa(E)	NTSC
Samoa(W)	SECAM
Singapore	PAL
Sri Lanka	PAL
Tahiti	SECAM
Taiwan	NTSC
Thailand	PAL
USA	NTSC
Vanuatu	PAL
Vietnam	NTSC

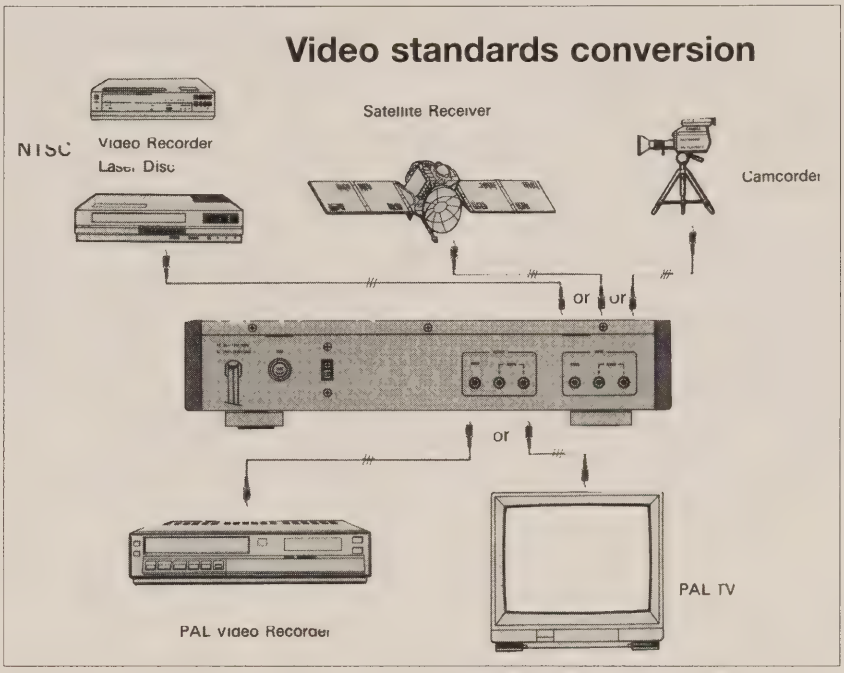
Table above shows the video standards used in the South Pacific and adjacent countries. Of course it is possible to view all international TV standard signals on a PAL monitor in black and white. However, if colour reception is required, either a multistandard monitor or a multi standard converter is required.

Multisystem video converters range from simple "subcarrier" types, which merely change the frequency of the colour burst signal, to more complex digital

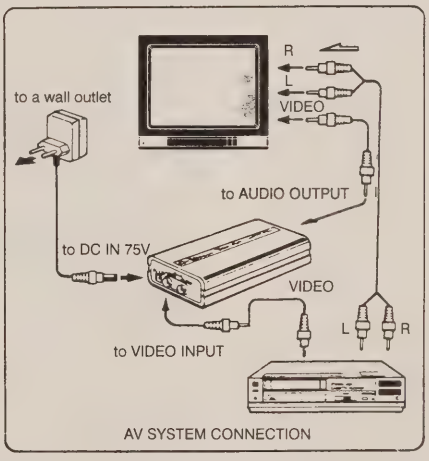
converters containing up to 4Mb of field memory, comb filtering, and which perform frame store and timebase correction functions.

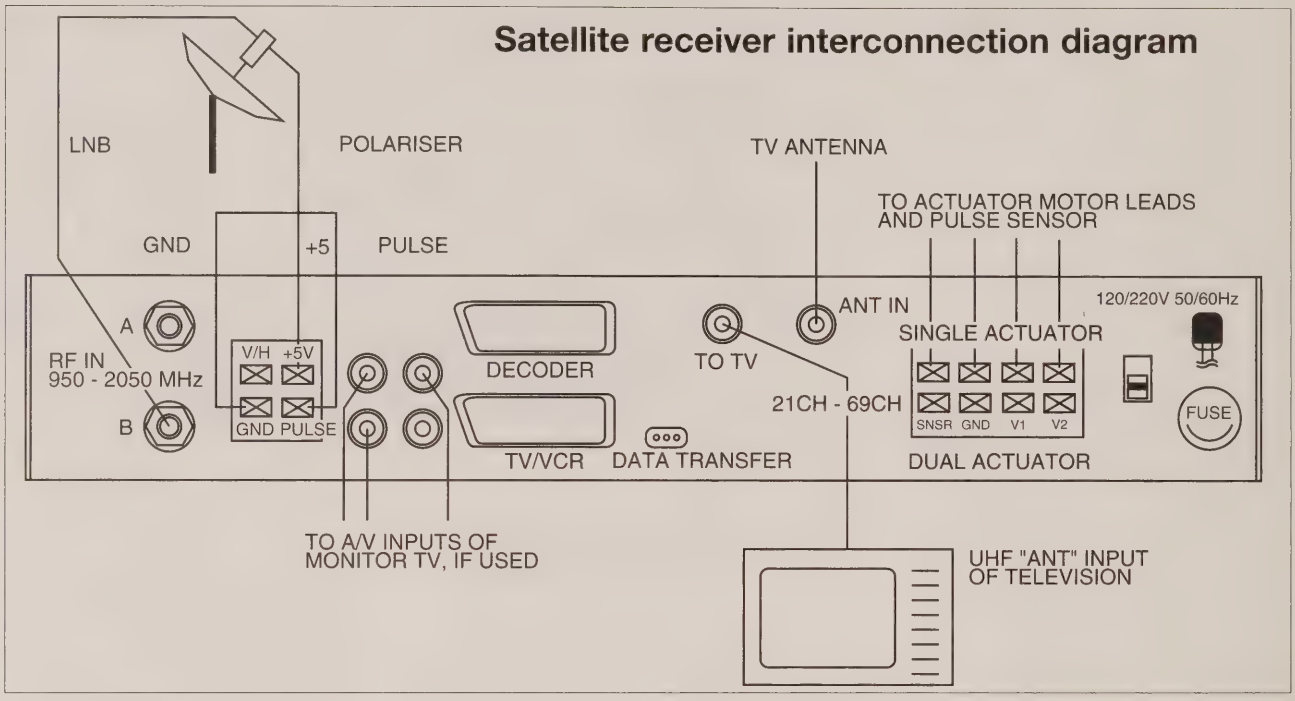
As technology has improved, the price of digital converters has dropped dramatically, to one tenth of the cost of such a device in 1990. Now, digital converters are available for less than $700, and can be used to view and record all video standards on PAL equipment.

This is by far preferable to the purchase of a multi-standard VCR and monitor. Once converted to PAL, satellite signals can be distributed using existing MATV equipment.



Digital Converter





External Wiring

After the site survey has been completed, and the dish located so that all desired satellites can be received, the electronics of the system must be wired.

Cables connecting the dish motors, LNB, and feedhorn must be routed in such a way that they cannot be damaged by animals or humans. In most installations, cables running between the dish and the receiver are buried underground in plastic conduit. Burying the conduit 200mm or so below the surface minimises the possibility of cable damage.

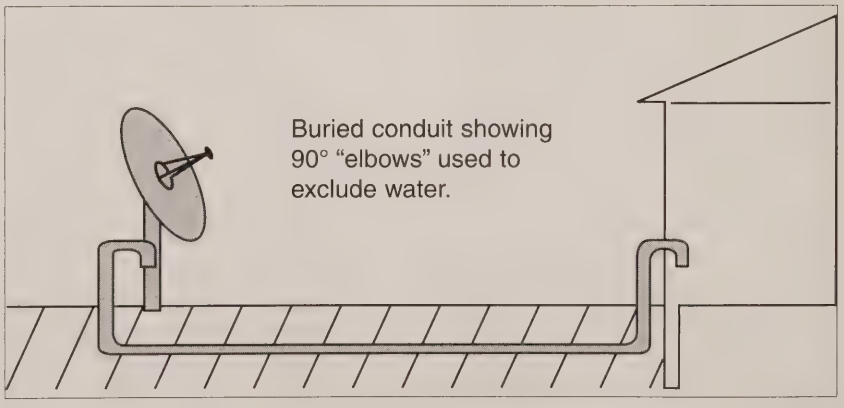
Conduit entry and exit points should be made 500mm or so above the surface, using two 90 degree elbows, so that no surface runoff can enter the conduit in the event of rain. The size of conduit used should be twice the collective diameter of the cable "bunch", to allow cables to be easily pulled through conduit sections prior to sealing and subsequent burial.

If future equipment upgrades are contemplated, such as dual band operation or dual axis dish motorisation, the additional cables to be used should be installed with the initial system wiring. It is almost impossible to pull extra cable through buried conduit.

Generally a suitable trench can be dug with common garden tools. However for long trenches, an automated trench digger, available from most equipment hire companies can be employed.

Where line amplifiers must be used it is always wise to externally mark the conduit with the position of the line amplifier should maintenance be required some time in the future.

It is wise to verify cable integrity by connecting the system components with all external cables running on top of the ground. This ensures any cable faults are located prior to burial.

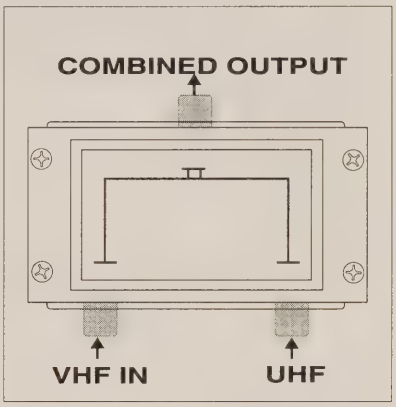


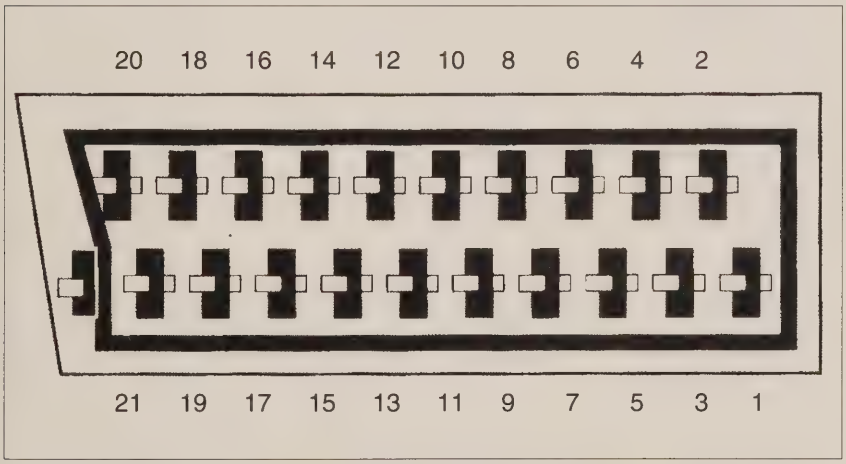
Internal Wiring

Most satellite receivers use either RCA sockets or SCART connectors to allow access to video, baseband and audio (left and right) signals. In addition most receivers have some means of directing either video and audio, or baseband output to an external decoder.

This "decoder ON/OFF" function is operated via the remote control. A SCART socket is the most convenient way of providing these outputs (to the decoder) and return input signals (from the decoder). This also allows signals that have been processed by an external decoder to be switched to the satellite receiver modulator.

and UHF sources into single output. Where the best possible video and audio fidelity from the satellite receiver is desired, direct video and audio connections should be made. The re-modulation process of an RF modulator does slightly degrade performance.





DECODER SCART Pin Out

01) Right Audio Out
02) Right Audio In
03) Left Audio Out
04) Audio Ground
06) Left Audio In
08) Switching Voltage
17) Baseband Out Ground
18) Comp. Video In Ground
19) Baseband Out
20) Composite Video In

In some installations the RF output of the satellite receiver will need to be combined with the RF output of other items such as VCR, Laserdisc etc. before connection to a TV set. RF combiners allow the mixing of signals from multiple VHF

Where signal distribution is performed with discrete composite video and line level audio outputs, a distribution amplifier should be used to ensure the correct output levels and impedance is preserved.

Maintenance

Most modern electronic items, once correctly installed, are extremely reliable. A home satellite TV system is no exception. Apart for regular dish inspection to ensure adequate bearing lubrication, re-application of rust and corrosion inhibitor and visual inspection of the dish surface, no maintenance is required.

Indoor equipment should be operated in a well ventilated location to prevent overheating, by allowing sufficient airflow around external casing. This is particularly true of integrated receiver/positioners, where heat dissipation is somewhat higher than normal.

If a fault does occur in a satellite receiving system, it can normally be traced to a recent "human" ocurrence involving spilt drinks, inadvertant lawnmowing accidents, etc.

Solar Outages

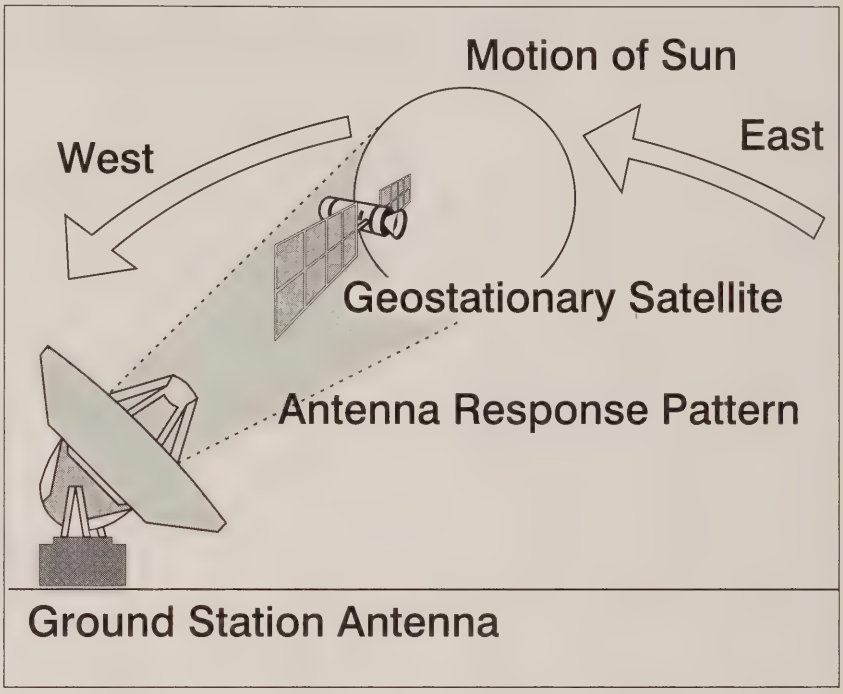
There are two occasions each year, when home satellite reception is affected by the sun. These periods occur after the vernal equinox and before the autumnal equinox.

At these times, and for a few days before and after the equinoxes, the sun is in alignment with both the satellite and the earth station. The Sun appears as a huge noise source, increasing the antenna noise temperature to the order of 10^4 degrees K. At 4 GHz, the solar radio emission from the sun is up to 20 dB in excess of the satellite TV signal being received. In some cases this can totally obliterate the satellite signal.

Solar interference can take place up to 21 days before and after both equinoxes, depending upon station latitude. Duration of the interference is usually 15 minutes or so, based on an antenna beamwidth of 2 degrees, and can last up to 30 minutes on smaller dishes having a wider beamwidth.

During periods of solar interference, care must be taken to ensure that satellite tracking equipment is placed in manual mode, at the particular time of interference, so that the tracker does not lock onto the interfering noise. If this were allowed to happen, the dish would track the sun as it appeared to move across the sky, instead of the satellite.

Figure 36 shows a graph, which allows the user to predict the time and date of solar equinoxes, for a particular location.



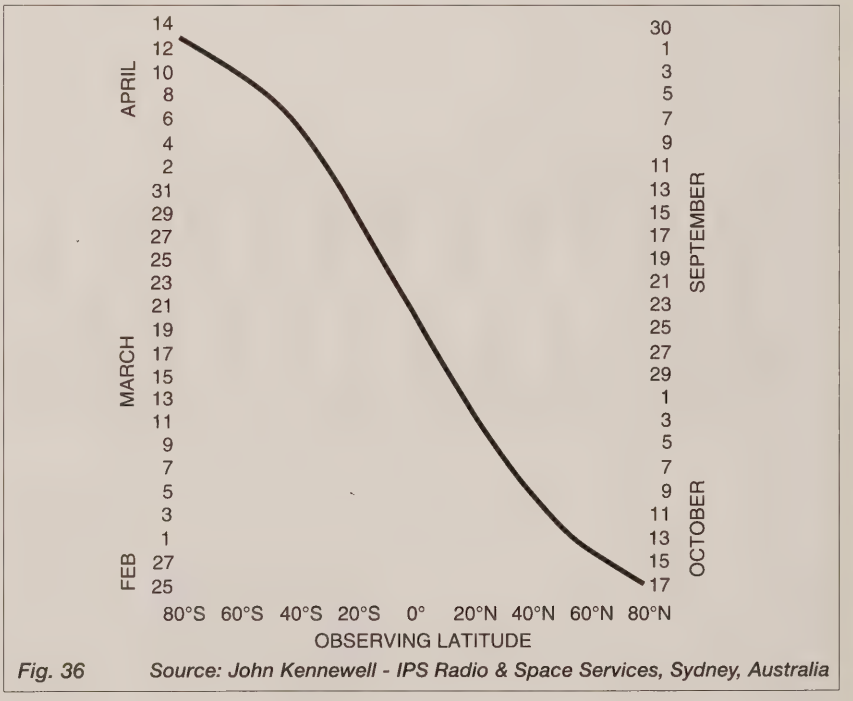


Fig. 36 *Source: John Kennewell - IPS Radio & Space Services, Sydney, Australia*

Glossary of terms

Actuator - external motor and gearbox driving a screw mechanism to produce lateral movement. Used to move dish in azimuth, elevation or both axes.

AFC - Abbreviation for automatic frequency control. An electronic circuit ensuring that a receiver stays locked onto a signal, once acquired, compensating for frequency drift.

AGC - Abbreviation for automatic gain control. An Electronic circuit which compensates for variation in signal levels, to provide a constant input level.

Algorithm - A set of predetermined steps for solving a mathematical problem.

Alignment - A process of fine tuning a circuit or component to maximise performance.

AM - Abbreviation for amplitude modulation.

Amplifier - A circuit for increasing the level of signal voltage or power.

Analogue - A method by which a variable is represented by continuous movement.

ANIK - Eskimo word meaning "brother".

Antenna - A device for either receiving or transmitting a signal.

Aperture - The total reflective area of a dish.

Apogee - The point in an elliptical orbit that is furthest from Earth.

Apogee Kick Motor - A small engine, operating on pressurised gas,affixed to a satellite and normally fired to propel the satellite from a low earth to geostationary orbit.

Attenuation - Signal reduction.

Attitude Contol - The orientation of the satellite in relationship to the earth and the sun.

Audio subcarrier - The frequency onto which audio information from a satellite transponder is superimposed. Generally within the range 5.5-9MHz.

Az/El mount - A dish mount having two adjustments, azimuth and elevation.

Azimuth - The angular displacement in the horizontal axis. In practice this means the east-west movement of a dish.

Backhaul - A terrestrial or satellite communication channel linking an earth station to a local switching network or population centre.

Backoff - The process of reducing the input and output power levels to obtain linear operation of a satellite.

Bandwidth - The range of frequencies passing through a transmission medium.

Bandpass filter - a filter which allows only signals contained within a certain band of frequencies to pass.

Baseband - The range of frequencies produced in a satellite receiver, after processing in the tuner. Subsequent processing of baseband signals results in both video and audio outputs. Baseband signals range from DC (zero) to 10MHz.

Boresight - The area of highest signal concentration of a downlink signal. Normally the centre of a satellite "footprint".

Cable TV - A method of distributing multiple channels of television down a coaxial cable, as distinct from satellite delivered TV signals.

CAM - Conditional Access Module.

Carrier to Noise ratio - The ratio of satellite signal power + noise to noise power. The C/N ratio is an indication of the efficiency of a satellite dish/LNB and Feed system.

Cassegrain antenna - A parabolic dish using a sub reflector at the focal point to reflect signals to the centre of the dish. Compared to a prime focus parabolic antenna, the cassegrain design offers improved efficiency.

C band - An internationally agreed frequency block for downlinking satellite signals, covering 3.4-4.2GHz. The corresponding 6GHz uplink block of frequencies is also known as C band.

CCIR - Abbreviation for Comite Consultant International des Radio Communications. The CCIR is part of the ITU.

Circular polarisation - A type of polarisation of satellite signals, used primarily by Intelsat and Russian Gorizont spacecraft. Abbreviated to either LHCP or RHCP (left or right hand circular polarisation).

Clarke Belt - The name given in honour of discoverer Arthur C Clarke, to the orbital belt 37,000Km in space above the equator.

Coaxial cable - A constant impedance cable used for the transmission of signals between pieces of equipment. The cable has a centre conductor separated by a dielectric material from the outer tubular shield.

Co-located - refers to 2 or more satellites in the same orbital location.

Companding - A method of dynamic range compression, used when bandwidth is limited. After transmission, the original dynamic range is restored without degradation, through an electronic expansion process.

Composite video - The complete video signal, including chrominance, luminance, and sync information.

COMSAT - Abbreviation for Communication Satellite Corporation. A corporation set up to represent US interests within INTELSAT.

Data compression - A method of transmitting data using fewer information bits without loss of intelligence. The received data is expanded to restore the original signal.

DBS - Abbreviation of Direct Broadcast Satellites.

dBw - Scientific notation meaning the number of decibels above 1 watt.

Decibel - Abbreviated to "dB"a unit of measurement used to express ratios logarithmically. A 3dB improvement represents doubling the signal power, a 10dB improvement is a tenfold increase, a 20dB improvement is a 100 fold increase.

Declination - Angle between the polar axis and reflector to ensure correct tracking of the orbital belt.

Decoder - A device which translates encoded signal information into a format that can be used by a standard receiver.

De-emphasis - One half of a system used to improve the video and audio signal to noise ratio of a signal by artificially emphasising the high frequency baseband components.

Demodulation - A process used to retrieve original information from a transmitted signal.

DES - Abbreviation for Data Encryption Standard. An encryption system utilising an algorithm described by the US National Bureau of Standards.

Dielectric - Insulating material used in coaxial cable to separate the outer shield from the centre conductor. This ensures the impedance of the cable remains constant. Dielectric material can also be used as a signal polariser in feedhorns.

Digital - Information in discrete form, normally in binary bits, ie "0" or "1".

Downlink - The path from the satellite in space, to earth.

DTH - Direct to home satellite service. Normally a high powered service, utilising K-band and requiring a small aperture dish.

ECM - Entitlement Control Message.

EMM - Entitlement Management Messages.

EIRP - Abbreviation for Effective Isotropic Radiated Power. A measure of the strength of a satellite signal, normally expressed in decibels above 1 watt (dBw).

Elevation - Angle made between the horizontal plane and the axis of the dish when pointed at a satellite.

Elliptical - Oval in shape (an elipse).

Encryption - A method of manipulating a satellite signal, for the purposes of security, so that it cannot be received without decoding equipment.

Equatorial orbit - Orbit around earth above the equator.

Express - Russian name for orbital locations reserved for "Express" class satellites.

F/D ratio - The ratio of the focal length to depth of a parabolic dish.

F.E.C. - A system of error control for data transmission, where the reciever can detect and correct any character that contains fewer than a pre determined number of symbols in error.

Accomplished by adding bits to each transmitted character or code block, using a pre determined algorithm.

Feedhorn - A mechanical focussing assembly, located at the entrance to the waveguide feeding signal to the LNB on a satellite dish.

Field - Electronic scanning of either odd or even lines of a television picture.

Figure of Merit - A measure of the quality of a dish performance. expressed as a ratio, G/T (gain/noise temperature).

Flat plate antenna - Satellite antenna either phased element or zone type, which appears to be flat, instead of curved.

FM - Abbreviation for frequency modulation.

FM improvement - The inherent noise reduction capacity of an FM receiving system. The maximum value approaches 39dB, when the signal is above threshold.

FM threshold - The level of input signal required to produce subjectively noise free pictures.

Focal length - The distance from the focal point to the centre of a dish.

Focal point - The point at which all signals reflected by the dish are focussed. The focal point is determined by the shape of the dish.

Footprint - the area on earth covered by a satellite signal.

Frame - The 625 lines (or 525 lines in the case of NTSC) that form a television picture.

GEO - Geostationary earth orbit.

Geostationary - A fixed position in space, relative to earth.

Geostationary Transfer Orbit - GTO, temporary elliptical orbit of a satellite, directly after launch, prior to geostationary insertion.

Gigahertz - A measure of frequency. 1GHz equals one billion hertz (cycles per second).

Gorizont - Russian for horizon.

Ground noise - Unwanted electronic noise generated by the earth.

G/T - Known as the "figure of merit", is the ratio of system gain to system noise.

HDTV - High Definition Television. A new video standard utilising 1200 scanning lines and 16:9 aspect ratio (screen format).

HEMPT - High Electron Mobility Transistor. Used in low noise amplifiers and LNBs.

Horn - A piece of waveguide, pyramidal in shape, which allows a gradual impedance change between free air and the low impedance input of an LNB.

Hyperbole - Convex reflector used as part of a Cassegrain reflector, to reflect incoming signals from the dish surface to the feedhorn.

IC - Integrated Circuit.

IF - Intermediate Frequency. A frequency or block of frequencies produced as a result of frequency conversion.

Impedance - The sum of the resistance and the reactance of either a capacitor or and inductor.

Inclined orbit - An orbit offset from the equator.

Inclinometer - an instrument used to measure dish elevation and declination.

INTELSAT - Stands for International Telecommunications Satellite Consortium.

K band - 12.25-12.75GHz for the Pacific Region (ITU region 3).

Kelvin (K) - A temperature scale where absolute zero, the temperature where all molecular activity stops =0 K. Absloute zero equals -273 degrees C.

LEO - Low earth orbit.

LNA - A term used in the early days of satellite equipment to refer to the Low Noise Amplifier section, now an integral part of a modern LNB.

LNB - Low Noise Block Converter. The device that amplifies and converts the incoming satellite signal to the block of IF frequencies presented to the satellite receiver.

LNC - A term used in the early days of satellite equipment to refer to the combination of low noise amplifier, and frequency converter in the one package. This was a tunable single frequency device, having an output centred around 70MHz.

Low Pass Filter (LPF.) - A filter allowing only signals below the nominal filter frequency, to pass.

Multiplexed Analogue Components (MAC.) - A broadcast standard using analogue picture and digital audio components. B-MAC is the variant used in the Pacific.

Main lobe - The signal response of a dish corresponding to the area directly in front of the reflector.

Molniya - Russian for "flash of lightning"

Mount - The structure used to support and aim the dish. Common types are Az/El, Polar, and Horizon to Horizon.

MPEG - A digital transmission standard devised by the Motion Picture Entertainment Group.

NTSC - US television standard utilising 525 scanning lines.

Offset antenna - Elliptical antenna, where the feedhorn assembly is offset from the reflector, to prevent aperture blockage.

Orthomode Coupler (OMT) - Specialised feedhorn allowing two LNBs to be mounted for simultaneous reception of vertical and horizontally polarised signals.

PAL - European broadcasting system used in Australia and New Zealand, utilising 625 scanning lines.

PAM - Payload assist module.

Parabola - Geometric shape utilised by most dish makers.

Phase Locked Loop - An electronic circuit capable of locking onto and tracking frequency variations of an input signal. Used in most satellite receivers.

Polar orbit - A satellite orbit perpendicular to the equator. Satellites using this track orbit the North and South poles.

Polarisation - The plane of vibration of the electric field of a signal radiated from a satellite antenna. Signals can be transmitted using vertical, horizontal, left hand circular or right hand circular polarisation.

Polariser - A device placed in the feedhorn to change the polarity of the incoming signal to that to which the LNB probe is aligned.

Positioner - The indoor unit used to control the operation of an actuator motor on the satellite dish. Positioners are also often integrated into modern satellite receivers.

Prime focus antenna - Parabolic antenna where the feedhorn and LNB are placed at the focal point of the dish. Sometimes called the "centre focus " antenna.

Raduga - Russian for "rainbow".

RF - Radio frequency. Any frequency falling between 100KHz and 100GHz.

SCART - Also known as the Euro or Peritel connector. A multi pin connector developed in France to allow easy interconnection between satellite receiver and external decoders.

SCPC - Single channel per carrier. A transmission system where a separate channel is allocated for the transmission of audio information.

SECAM - French television standard.

Sidelobe - Response of an antenna to satellite signals arriving at the antenna "off axis".

S/N - Signal to Noise ratio. The ratio of signal + noise to noise power, expressed in dB. The quality of audio and video signals can be described using this measurement.

Skew - A method of rotating a pickup probe coupled to the LNB so that it is in alignment with the incoming satellite signal.

Slot - Slang for "orbital location".

SMATV - Satellite Master Antenna TV. The headend where satellite signals are received and subsequently transferred into an existing TV antenna/distribution system.

SNG - Satellite News Gathering Unit. Typically a mobile uplink van, capable of uplinking directly to the satellite.

Sparklies - Impulse noise caused by insufficient signal. Manifested visually as black and white dots superimposed on a satellite signal.

Spherical antenna - Spherical shaped antenna with multiple focus points, intended to receive multiple signals simultaneously.

Symbol Rate (SR) - The rate of data transmission based on the number of signal elements or symbols transmitted per second.

Statsionar - Soviet name meaning stationary, used for orbital locations reserved for Raduga & Gorizont satellites.

Stationkeeping - Process performed by ground control stations, where command signals are uplinked operating pressurised gas thrusters to keep the satellite "on station".

Threshold - Subjectively, the minimum C/N ratio required for a satellite receiver to deliver a locked colour picture.

Transponder - A spaceborne repeater. Signals received are amplified, frequency converted, and retransmitted.

TVRO - TV receive only. A satellite system designed only to receive signals, not transmit.

Uplink - The earth to satellite segment of the satellite circuit.

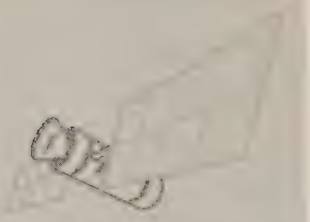
Videocrypt - A cut and rotate encryption system, designed for use with PAL TV signals delivered by satellite.

Waveguide - A tube of precise dimensions, used to conduct microwave signals.

Zenith - Highest point.

LOCATED AT 185.7 DEGREES EAST LONGITUDE

Launch Date	02/08/91	Country of Origin	USA
Launch Vehicle	Shuttle STS 43	Satellite Type	TRW
Mass in Orbit	2120Kg	Stabilisation	3 Axis
Design Lifetime	10 Years	US Space Command # 25473	



TRANSPONDERS

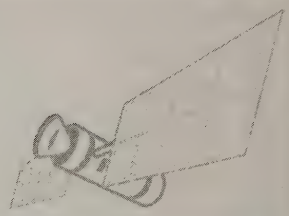
C Band	12
Power	5W
Bandwidth	36MHz
Coverage	POR
Polarisation	Linear
K Band	6
Backup	4
Power	1.5/25W
Bandwidth	50/255MHz
Coverage	POR
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO
6	H	3915	APTV	563	3/4	PAL	
8	H	4000	ITJ	7700	3/4	NTSC	

INTELSAT 513

LOCATED AT 183.0 DEGREES EAST LONGITUDE

Launch Date	17/05/88	Country of Origin	International
Launch Vehicle	Ariane V22	Satellite Type	Intelsat 5A
Mass in Orbit	1040Kg	Stabilisation	3 Axis
Design Lifetime	7 Years	US Space Command #	19121



TRANSPONDERS

C Band	16	
Backup	4	
Power	34W	
Bandwidth	12 x 54MHz	
	4 x 64MHz	
Coverage	Oceania/Pacific	
Polarisation	Linear	
K Band	16	
Backup	4	
Power	63W	
Bandwidth	12 x 54MHz	
	4 x 64MHz	
Coverage	China/Australia	&
Polarisation	Linear	

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO

No Video transmissions observed.

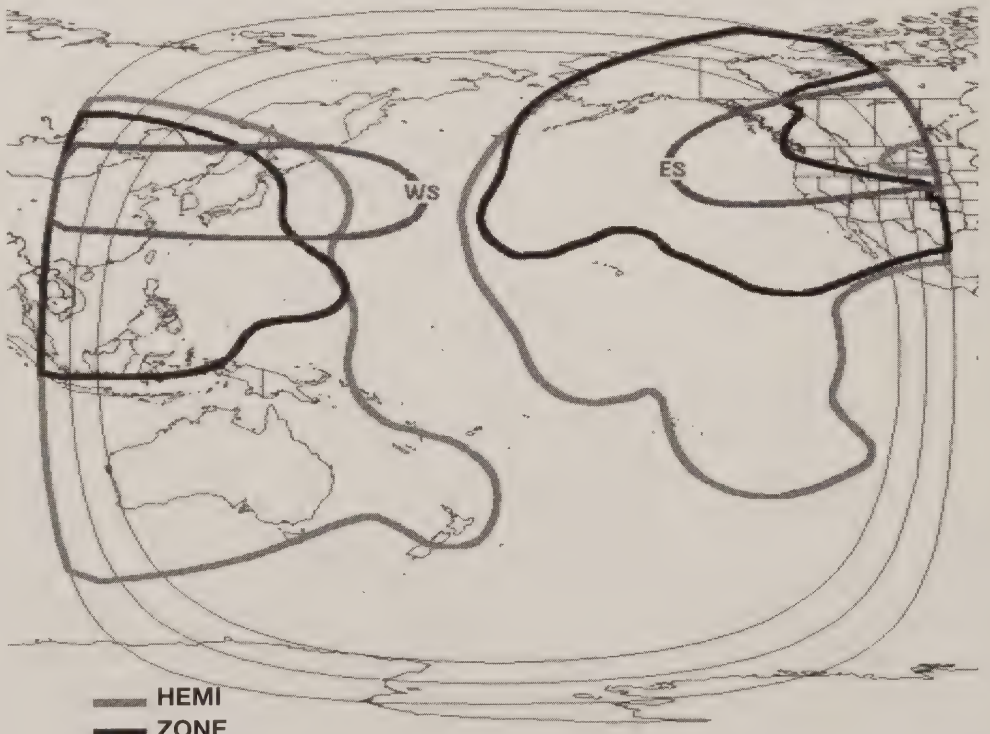
History

Initial position 53°W.
August 1995 moved to 183° Inclined.

Capacity

15000 Telephone Circuits.
2 Television transponders.

Ownership of this satellite transferred to New Skies Satellites, N.V. October 1998.

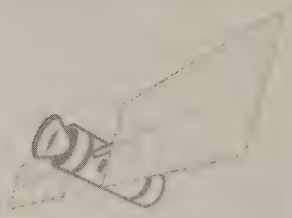


Original Source: Intelsat www

INTELSAT 701

LOCATED AT 180 DEGREES EAST

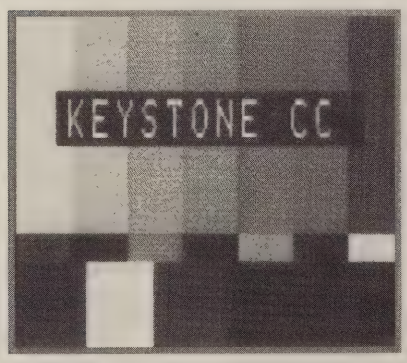
Launch Date	22/10/93	Country of Origin	International
Launch Vehicle	Ariane V60	Satellite Type	FS 1300
Mass in Orbit	1800Kg	Stabilisation	3 Axis
Design Lifetime	15 Years	US Space Command #	22871

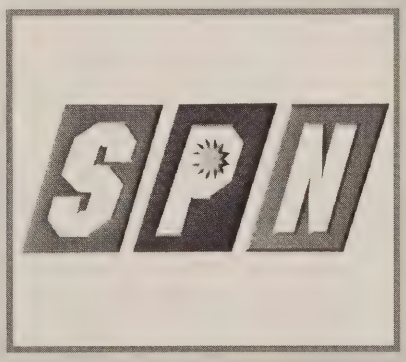


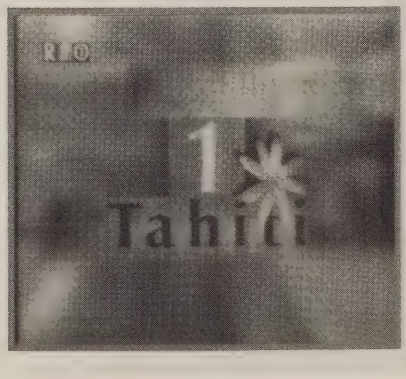
TRANSPONDERS

C Band	28
Power	10/16/20/30W
Bandwidth	10 x 36MHz
	2 x 41MHz
	16 x 72MHz
Coverage	POR
Polarisation	Circular
K Band	10
Power	5 x 35W
	5 x 55W
Bandwidth	6 x 72MHz
	4 x 112MHz
Coverage	POR
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO
11L	RHCP	3720	CNN FEEDS			NTSC	6.6
			KLOS FM				5.4/5.6
41	LHCP	3740	GLOBECAST FEEDS			NTSC	6.6
11U	RHCP	3764	10 NETWORK FEEDS	29895	7/8	NTSC	
	RHCP	3764	ABC TV FEEDS	29895	7/8	NTSC	
	RHCP	3764	ABC TV FEEDS	29895	7/8	NTSC	
	RHCP	3764	TV3 NZ FEEDS	29895	7/8	NTSC	
	RHCP	3764	GLOBECAST FEEDS	29895	7/8	NTSC	
13B	RHCP	3930	NETWORK 9 AUST			MACROVISION	
36	RHCP	4081	SPN	4730	3/4	PAL	
86	LHCP	4095	RFO 1	27500	3/4	PAL	
	LHCP	4095	RFO 2	27500	3/4	PAL	
	LHCP	4095	RFO 3	27500	3/4	PAL	
	LHCP	4095	SAUDI TV	27500	3/4	PAL	
	LHCP	4095	ABU DHABI	27500	3/4	PAL	
			RADIO ABU DHABI				
			RADIO IMARAT FM				

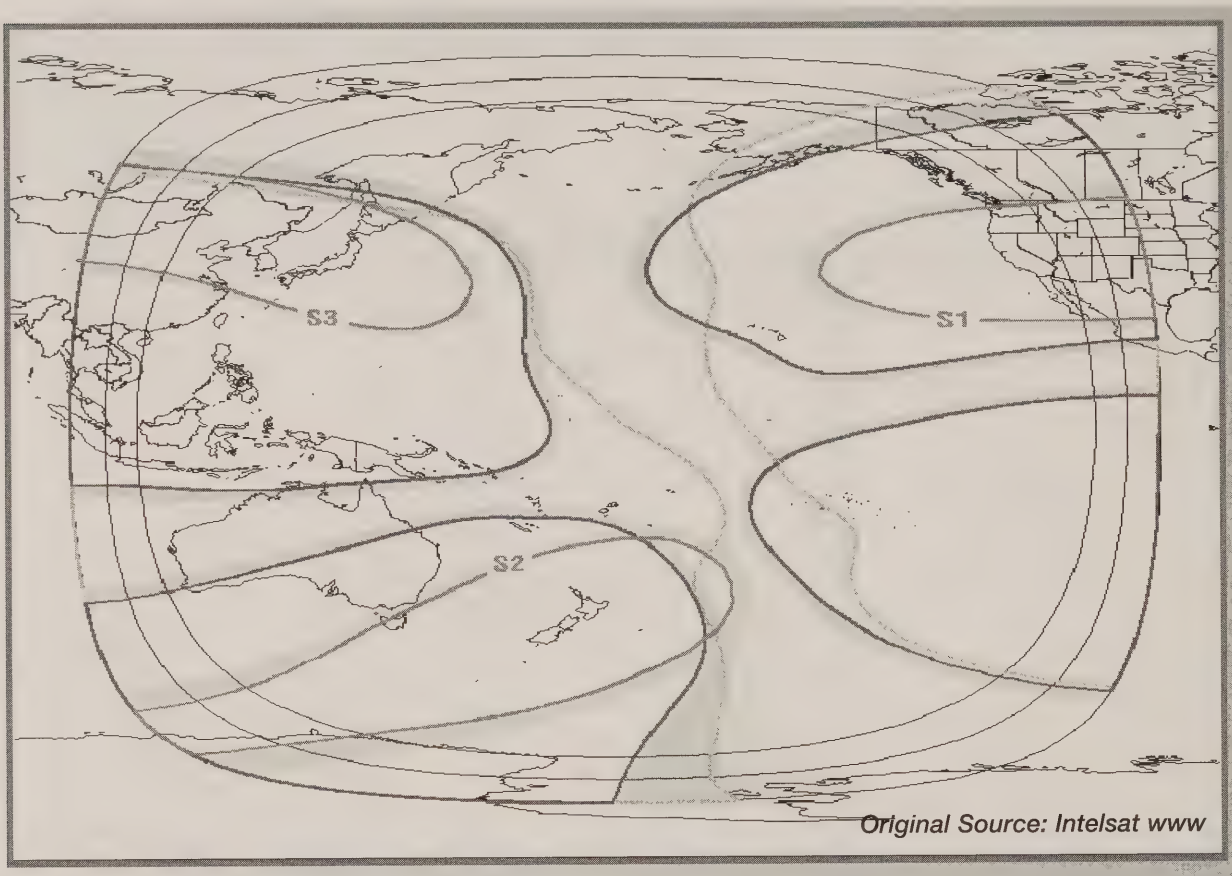






INTELSAT 701

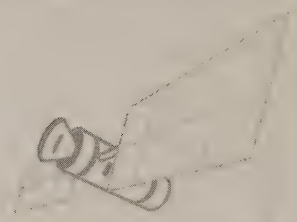
LOCATED AT 180.0 DEGREES EAST LONGITUDE



INTELSAT 702

LOCATED AT 177.0 DEGREES EAST LONGITUDE

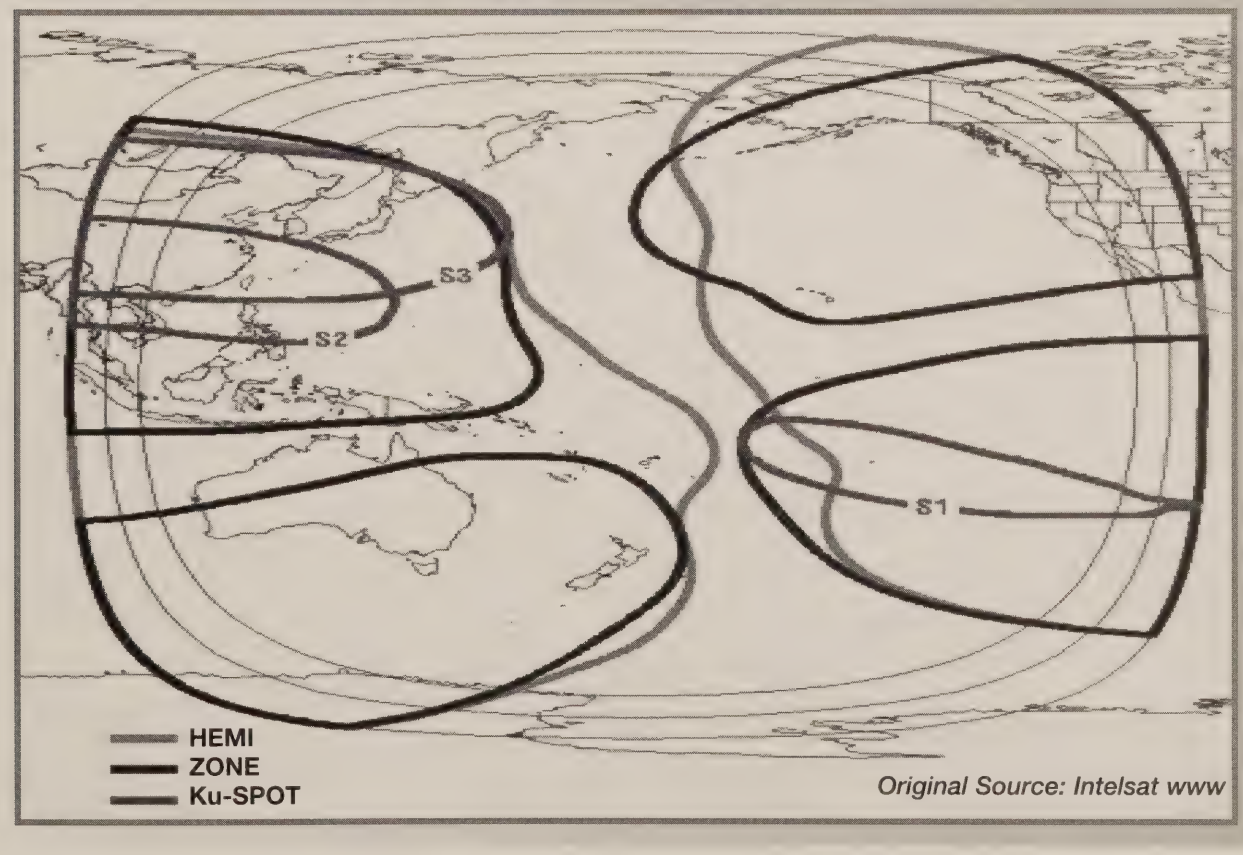
Launch Date	17/06/94	Country of Origin	International
Launch Vehicle	Ariane V64	Satellite Type	FS 1300
Mass in Orbit	1900Kg	Stabilisation	3 Axis
Design Lifetime	10-15 Years	US Space Command #	23124



TRANSPONDERS

C Band	26
Backup	0
Power	7 x 35W
	8 x 50W
Bandwidth	16 x 72MHz
	10 x 36MHz
Coverage	POR
Polarisation	Circular
K Band	10
Backup	0
Power	50W
Bandwidth	6 x 72MHz
	4 x 112MHz
Coverage	POR
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO
88	LHCP	4177	AFRTS	28000	3/4	POWERVU CA	
88	RHCP	4166	VARIOUS		3/4	NTSC	6.60
	H	12650	THAI TV5	17800	1/2	PAL	

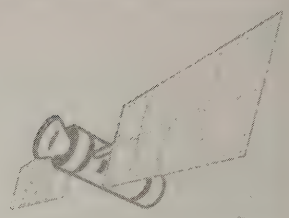


Original Source: Intelsat www

INTELSAT 802

LOCATED AT 174.0 DEGREES EAST LONGITUDE

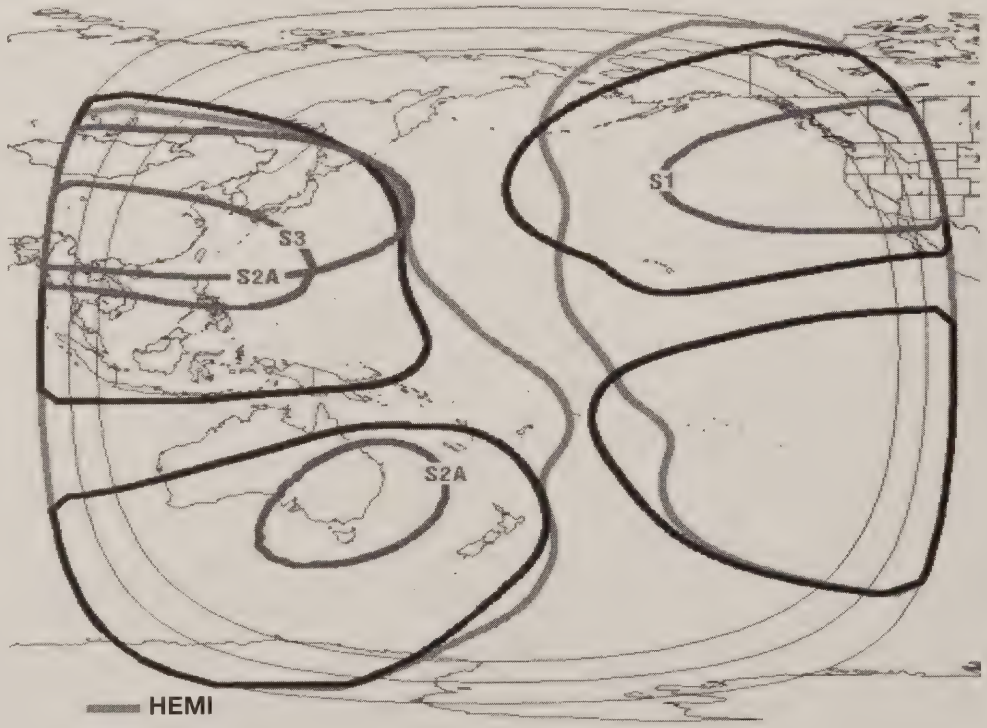
Launch Date	25/6/97	Country of Origin	International
Launch Vehicle	Ariane V96	Satellite Type	FS-1300
Mass in Orbit	3400Kg	Stabilisation	3 Axis
Design Lifetime	12 Years	US Space Command # 24846	



TRANSPONDERS

C Band	38
Power	7/22/27/38W
Bandwidth	8 x 36MHz
	4 x 41MHz
	16 x 72MHz
Coverage	POR
Polarisation	Circular
K Band	6
Power	43W
Bandwidth	72MHz/112MHz
Coverage	POR
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
38L	RHCP	4166	FEEDS	NTSC	6.60
384	RHCP	4187	FEEDS	NTSC	6.60

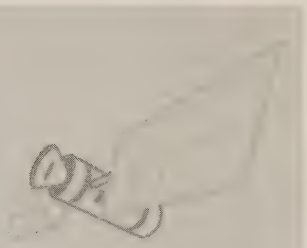


www.intelsat.int/com/info/802maps.htm

Original Source: Intelsat www

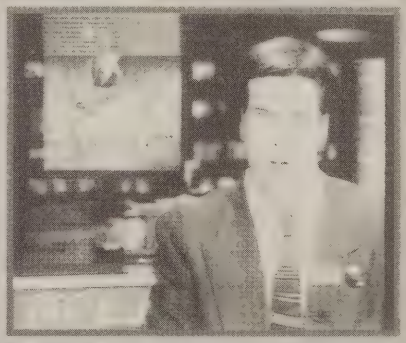
LOCATED AT 169.0 DEGREES EAST LONGITUDE

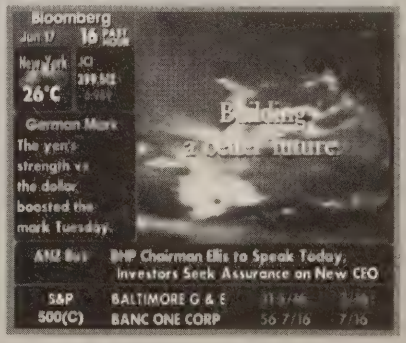
Launch Date	08/07/94	Country of Origin	United States
Launch Vehicle	Ariane V65	Satellite Type	HS-601
Mass at Launch	2920Kg	Stabilisation	3 Axis
Design Lifetime	15 Years	US Space Command #	23175



TRANSPONDERS	
C Band	16
Backup	4
Power	34W
Bandwidth	12 x 54MHz
	4 x 64MHz
Coverage	Oceania/Pacific
Polarisation	Linear
K Band	16
Backup	4
Power	63W
Bandwidth	12 x 54W
	4 x 64MHz
Coverage	China/Australia
& S.Korea+Asia	
Polarisation	Linear H/V

XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO
1L	V	3716	CCTV 3, 4, 9	19850	3/4	PAL	
1U	V	3743	BBC	21800	3/4	PAL	
3L	V	3778	LBC AUSTRALIA	13331	3/4	PAL	
			ART AUSTRALIA				
			RAI				
			ANTENNA				
7L	H	3900	CMT	30800	3/4	NTSC	
			ADHOC FEEDS	30800	3/4	NTSC	
			EWTN	30800	3/4	NTSC	
			BLOOMBERG	30800	3/4	NTSC	
7L	H	3905	CNN INTERNATIONAL			NTSC	6.8/6.3
8U	V	3942	PANAMSAT FEEDS	6620	2/3	NTSC	
10U	H	3967	FEEDS			NTSC	6.8
12	H	4035	NHK WORLD	26470	3/4	NTSC/PAL	
12U	H	4062	NAPA FEEDS				
13	V	4093	CNBC ASIA	29473	3/4	PAL	
			CNBC AUSTRALIA				
			NATIONAL GEOGRAPHIC				
16	H	4174	JAPAN TELECOM (ITS)	5632	3/4	NTSC	
16	H	4183	TCS SINGAPORE	6620	1/2	NTSC	
			K BAND				
14	V	12629	ABC AUST INTCHANGE	6980	3/4		
		12367	ABC AUST INTCHANGE	6980	3/4		
		12646	ABC AUST INTCHANGE	6980	3/4		
15	H	12655	INTINERANT FEEDS	6620	2/3		



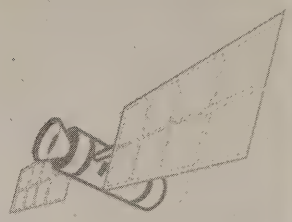

Bloomberg
26°C
German Mark
The yen's strength vs the dollar boosted the mark Tuesday.
BHP Chairman Ellis to Speak Today; Investors Seek Assurance on New CEO
S&P 500(C)
BALTIMORE G & E
BANC ONE CORP

LOCATED AT 169.0 DEGREES EAST LONGITUDE

PANAMSAT 8

LOCATED AT 166 DEGREES EAST LONGITUDE

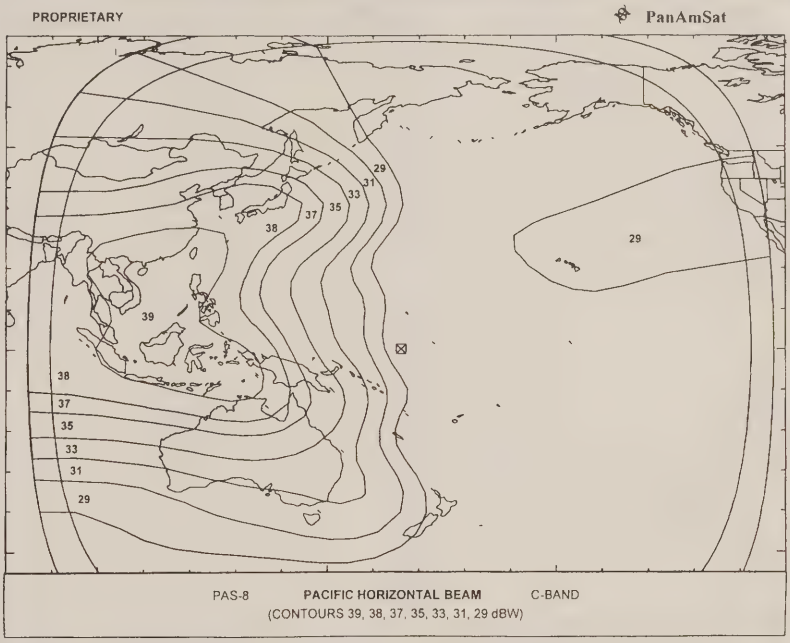
Launch Date	4/11/98	Country of Origin	USA
Launch Vehicle	Proton	Satellite Type	FS 1300
Mass in Orbit	1500Kg	Stabilisation	3 Axis
Design Lifetime	15 Years	US Space Command #	25522

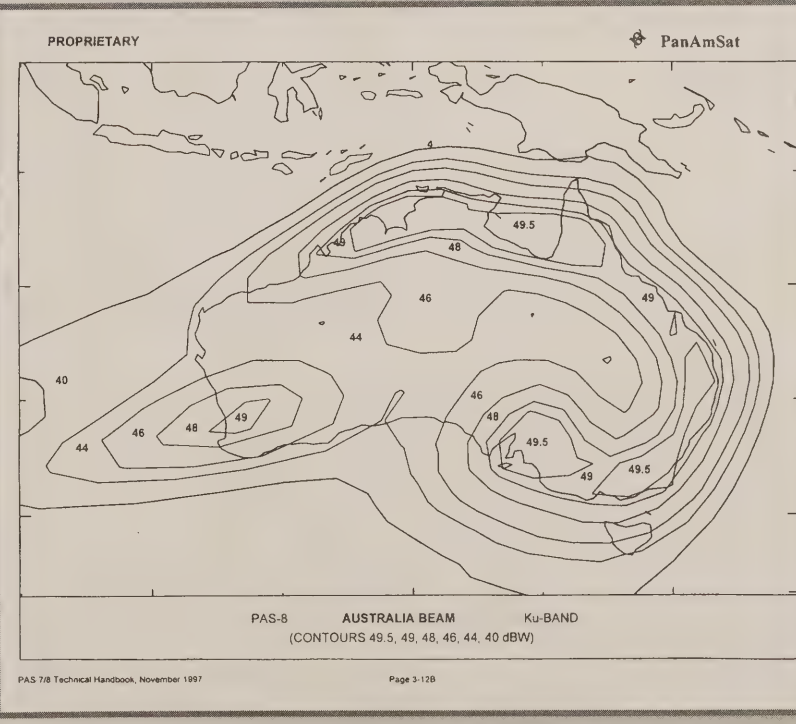


TRANSPONDERS

C Band	24
Power	50W
Bandwidth	24 x 36MHz
Coverage	Asia/Australia
Polarisation	Linear

K Band	24
Power	100W
Bandwidth	24 x 36MHz
Coverage	Asia/Pacific
Polarisation	Linear

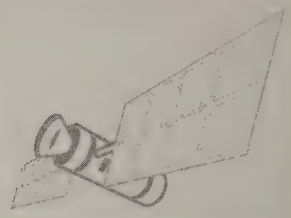




OPTUS A2

LOCATED AT 164.0 DEGREES EAST LONGITUDE

Launch Date	27/11/85	Country of Origin	Australia
Launch Vehicle	Shuttle STS 31	Satellite Type	HS 376
Mass in Orbit	655Kg	Stabilisation	Spin
Design Lifetime	7 Years	US Space Command #	16275



TRANSPONDERS

K Band	15
Backup	4
Power	12/30W
Bandwidth	45MHz
Coverage	Australia/PNG
	New Zealand
Polarisation	Linear

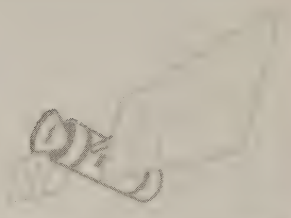
History

Previously called AUSSAT A2.
Original position 156° East.
February 1995 moved to 164°
Inclined.

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
1	V	12277			
2	V	12341			
3	V	12405			
4	V	12469			
5	V	12533			
6	V	12597			
7	V	12661			
8	V	12725			
9	H	12309			
10	H	12373			
11	H	12437			
12	H	12501			
13	H	12565			
14	H	12629			
15	H	12693			

LOCATED AT 160.0 DEGREES EAST LONGITUDE

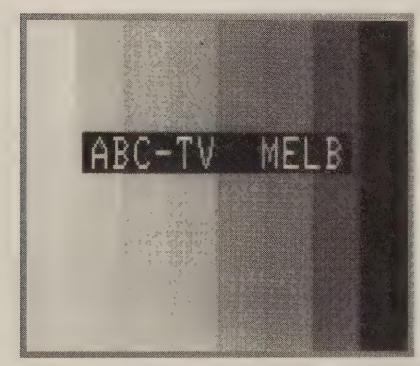
Launch Date	13/08/92	Country of Origin	Australia
Launch Vehicle	Long March 2E	Satellite Type	HS 601
Mass in Orbit	1582Kg	Stabilisation	3 Axis
Design Lifetime	13 Years	US Space Command #	22087

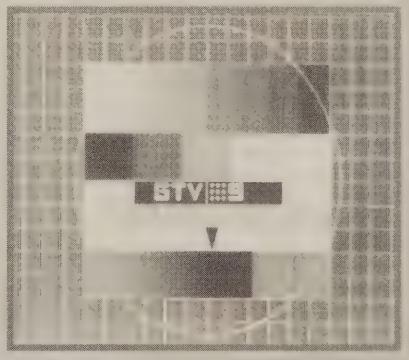


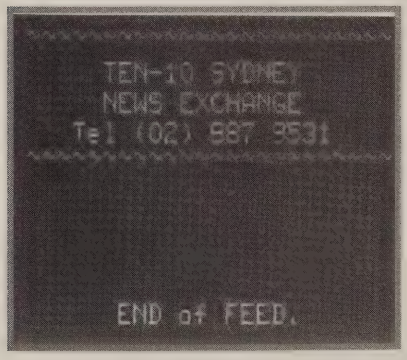
TRANSPONDERS

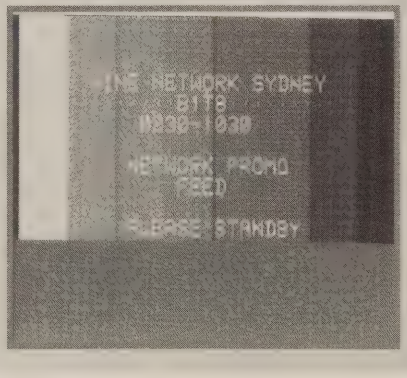
K Band	15
Backup	0
Power	50W
Bandwidth	54MHz
Coverage	Australia
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
10U	H	12386	NETWORK 7	E-PAL	7.38/7.56
3L	V	12391	SKY NZ	SR 22500 FEC 3/4	PAL
11L	H	12426	NETWORK 9 FEEDS	PAL	7.38/7.56
11U	H	12448	FEEDS	PAL	7.38/7.56
4L	V	12455	10 INTERCHANGE	PAL	7.38/7.56
4U	V	12480	NETWORK 10	E-PAL	7.38/7.56
12	H	12488	NETWORK 9	E-PAL	7.38/7.56
5L	V	12519	SKY NZ	PAL/VC	7.38/7.56
12U	H	12519	NETWORK 9 FEEDS	PAL	6.60
5U	V	12546	SKY NZ	PAL/VC	7.38/7.56
14L	H	12613	ABC NE	B-MAC	
14U	H	12639	SBS NE	B-MAC	
7L	V	12644	ABC SE	B-MAC	
7U	V	12670	SBS SE	B-MAC	
15L	H	12677	QSTV	B-MAC	
8	V	12725	9 INTERCHANGE	PAL/B-MAC	7.38/7.56



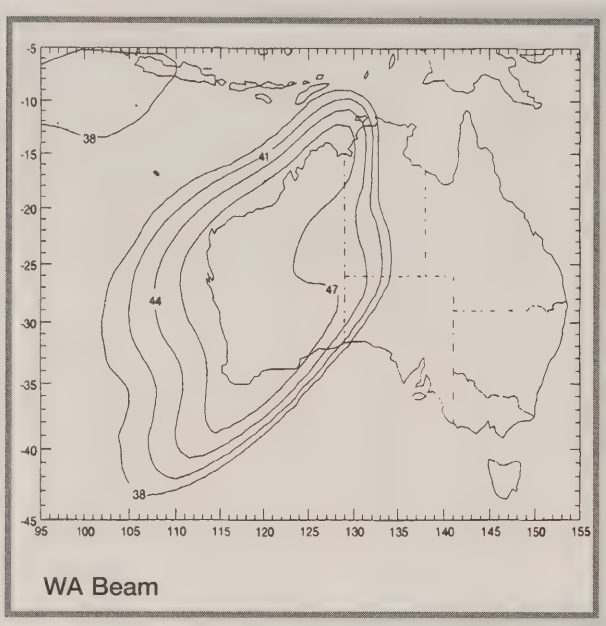


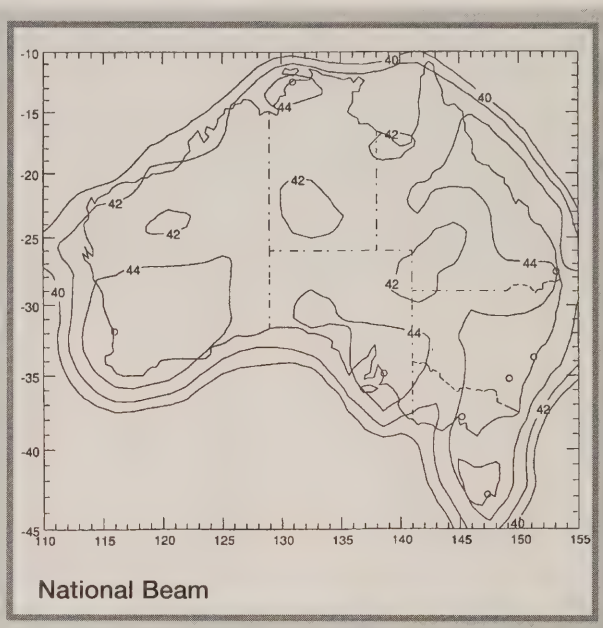


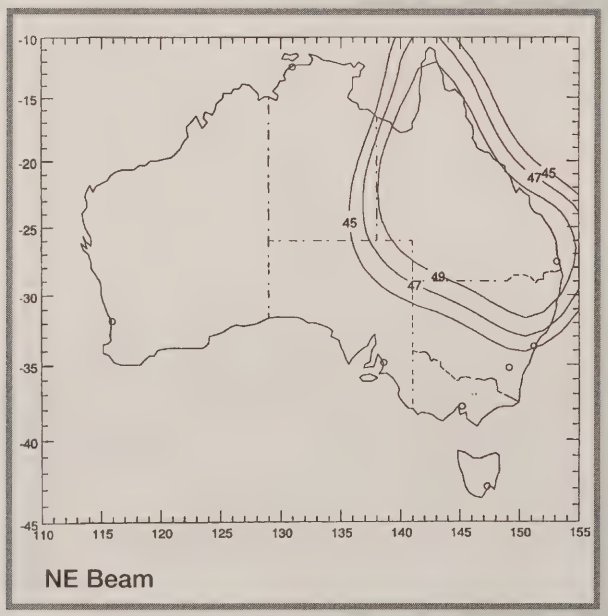


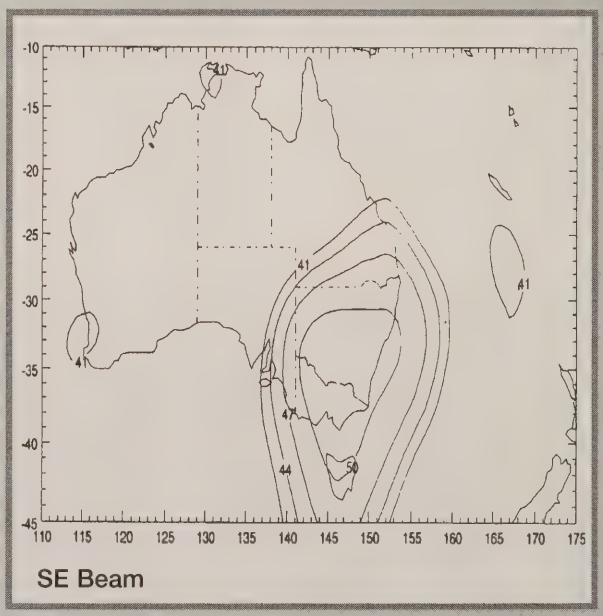
OPTUS B1

LOCATED AT 160.0 DEGREES EAST LONGITUDE



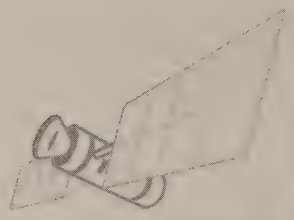






Source: OPTUS B Overview of Payload Performance.

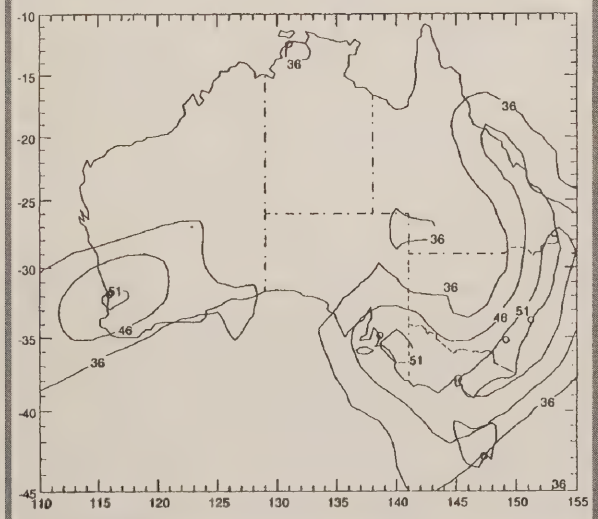
Launch Date	27/08/94	Country of Origin	Australia
Launch Vehicle	Long March 2E	Satellite Type	HS 601
Mass in Orbit	1582Kg	Stabilisation	3 Axis
Design Lifetime	13 Years	US Space Command #	23227



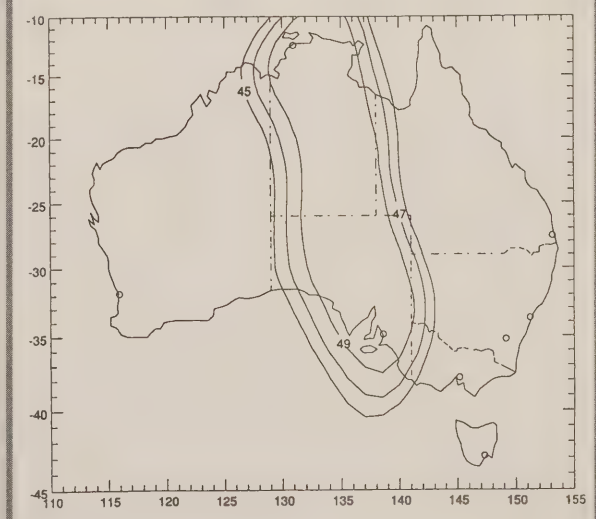
TRANSPONDERS

K Band	15
Backup	0
Power	50W
Bandwidth	54MHz
Coverage	Australia
Polarisation	Linear

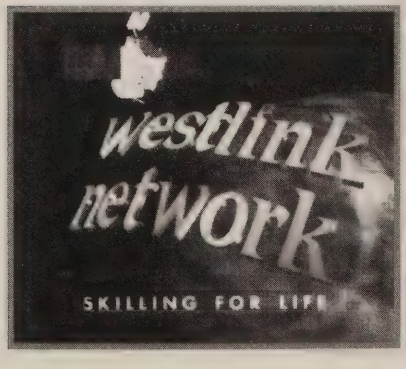
XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO
2U	V	12355	IMPARJA TV			B-MAC	
3	V	12407	AURORA	30000	2/3	IRDETO CA	
12L	H	12487	ABC NT			B-MAC	
12U	H	12514	IMPARJA TV			B-MAC	
13	H	12564	AUSTAR	29473	3/4	IRDETO CA	
14	H	12626	AUSTAR	29473	3/4	IRDETO CA	
7	V	12658	ABC WA			B-MAC	
15	V	12689	AUSTAR	29473	3/4	IRDETO CA	



HP Beam



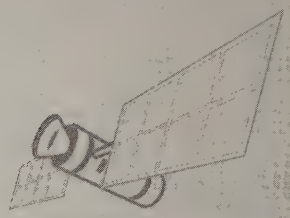
CA Beam



OPTUS A3

LOCATED AT 152.0 DEGREES EAST LONGITUDE

Launch Date	16/09/87	Country of Origin	Australia
Launch Vehicle	Ariane V19	Satellite Type	HS 376
Mass in Orbit	655Kg	Stabilisation	Spin
Design Lifetime	10 Years	US Space Command #	18350



TRANSPONDERS

K Band	15
Backup	4
Power	12/30W
Bandwidth	45
Coverage	Australia/NZ/PNG
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
1	V	12277			
2	V	12341			
3	V	12405			
4	V	12469			
5	V	12533			
6	V	12597			
7	V	12661			
8	V	12725			
9	H	12309			
10	H	12373			
11	H	12437			
12	H	12501			
13	H	12565			
14	H	12629			
15	H	12693			

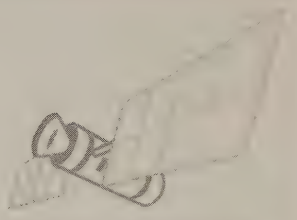
History

Previously called AUSSAT A3.
Original position 164° East.
February 1995 moved to 156° East.
Augüst 1995 moved 152° East Inclined.

PALAPA C1

LOCATED AT 150.5 DEGREES EAST LONGITUDE

Launch Date	01/02/96	Country of Origin	Indonesia
Launch Vehicle	Atlas Centaur #98	Satellite Type	HS 601
Mass in Orbit	1800Kg	Stabilisation	3 Axis
Design Lifetime	14 Years	US Space Command #	23779



TRANSPONDERS

C Band	30
Backup	8
Power	24 x 21.5W
	6 x 26.75W
Bandwidth	36MHz
Coverage	Asia/Indonesia
	Aust./N.Zealand
Polarisation	Linear
K Band	4
Backup	2
Power	130W
Bandwidth	72MHz
Coverage	H.Kong/Thailand
	Indonesia
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO
11	H	4117	INDOVISION	26850	7/8	NDS CA	
12	H	4160	ITINERANT				

HISTORY

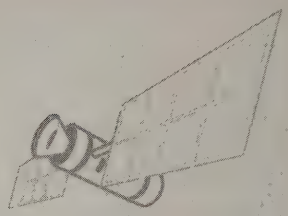
Initial position 113 E

July 1996 moved to 150.5 E

JCSAT 4

LOCATED AT 150 DEGREES EAST LONGITUDE

Launch Date	17/2/97	Country of Origin	Japan
Launch Vehicle	Atlas 2AS	Satellite Type	HS-601
Mass in Orbit	1200Kg	Stabilisation	3 Axis
Design Lifetime	12 Years	US Space Command #	24732



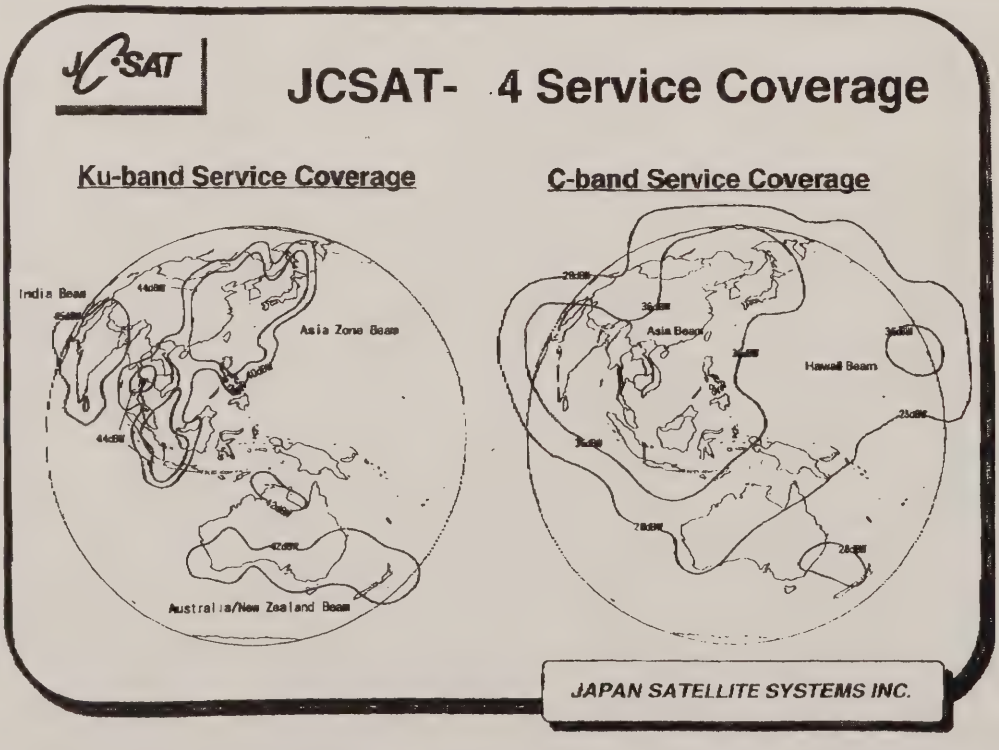
TRANSPONDERS

C Band	12
Power	34W
Bandwidth	12 x 36MHz
Coverage	Asia/Australia
Polarisation	Linear
K Band	28
Power	60/90W
Bandwidth	8 x 36MHz 16 x 27MHz
Coverage	Eastern Asia, India, Australia
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO

HISTORY

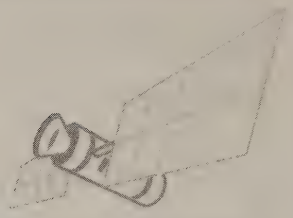
Initial position 141 E
Feb 1998 moved to 150 E
Final location will be 124 E



MEASAT 2

LOCATED AT 148.0 DEGREES EAST LONGITUDE

Launch Date	14/11/96	Country of Origin	Malaysia
Launch Vehicle	Ariane V92	Satellite Type	HS 376
Mass at Launch	1450Kg	Stabilisation	Spin
Design Lifetime	11.5 Years	US Space Command #	24653

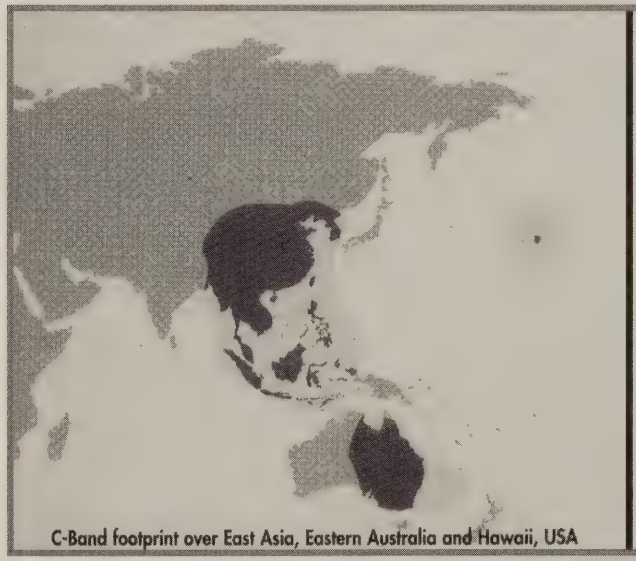


TRANSPONDERS

C Band	6
Power	12W
Bandwidth	6 x 72MHz
Coverage	Malaysia/N.Aust Vietnam/Indonesia
Polarisation	Linear
K Band	9
Power	12W
Bandwidth	50MHz
Coverage	Philipines/Australia Taiwan/Vietnam Indonesia
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO
M2	H	11044	JET TV	30000	7/8	PAL	
M3	H	11106	ASTRO	30000	7/8	PAL	
M4	H	11168	RPN 9	30000	7/8	PAL	

Transponders listed above not visible in Australia



C-Band footprint over East Asia, Eastern Australia and Hawaii, USA

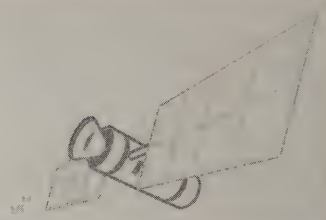
Ku-Band footprint over West Malaysia, Indonesia (Sumatra, Jawa), Philippines, Vietnam, Eastern Australia and Taiwan

Original Source: Measat

AGILA 2

LOCATED AT 146.0 DEGREES EAST LONGITUDE

Launch Date	20/08/97	Country of Origin	USA
Launch Vehicle	Long March 3B	Satellite Type	FS 1300
Mass in Orbit	1800Kg	Stabilisation	3 axis
Design Lifetime	12 Years	US Space Command # 24901	



TRANSPONDERS

C Band	30
Power	27W
Bandwidth	36MHz
Coverage	Philippines
Polarisation	Linear
K Band	24
Power	110W

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
4	H	3787	GMA	NTSC	6.80

GORIZONT 21

LOCATED AT 145.0 DEGREES EAST LONGITUDE

Launch Date	03/11/90	Country of Origin	CIS
Launch Vehicle	Proton #191	Satellite Type	NPO PM
Mass in Orbit	2120 Kg	Stabilisation	3 Axis
Design Lifetime	3-5 Years	US Space Command # 20923	

TRANSPONDERS

C Band	6
Power	65W
Bandwidth	5 x 36MHz
	1 x 40MHz
Coverage	CIS/Asia
Polarisation	Circular
K Band	1
Power	65W
Bandwidth	36MHz
Coverage	CIS
Polarisation	Circular

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
6	RHCP	3675	ORT-1	SECAM	7.02/7.50*
10	RHCP	3875	OCCASIONAL USE	SECAM	7.02

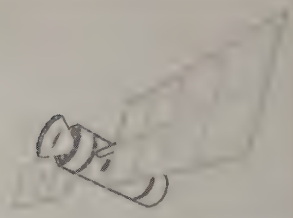
* Radio Service

Estimated Values

GORIZONT 22

LOCATED AT 140.0 DEGREES EAST LONGITUDE

Launch Date	05/07/89	Country of Origin	CIS
Launch Vehicle	Proton #179	Satellite Type	NPO PM
Mass in Orbit	2120 Kg	Stabilisation	3 Axis
Design Lifetime	3-5 Years	US Space Command #	20953

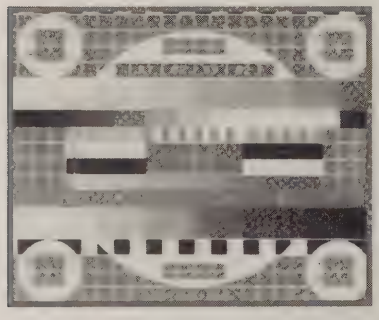


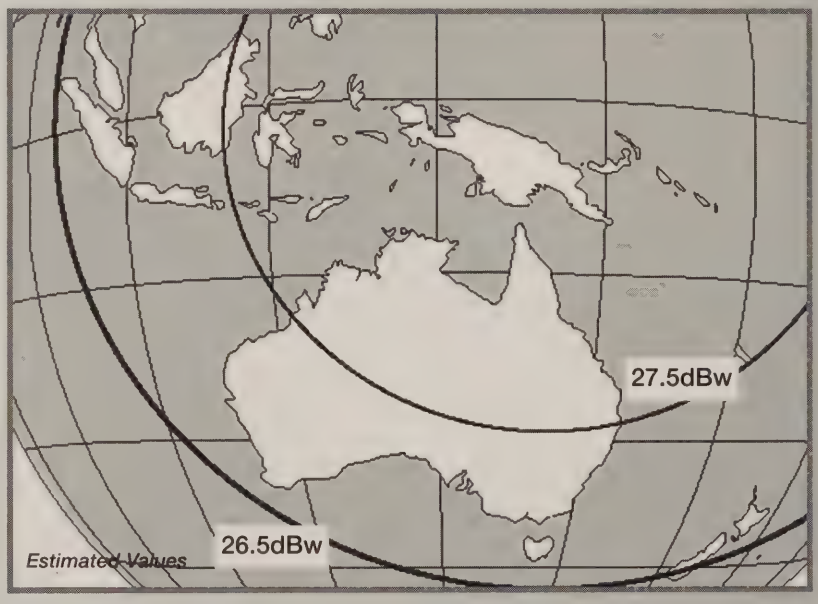
TRANSPONDERS

C Band	6
Power	65W
Bandwidth	5 x 36MHz
	1 x 40MHz
Coverage	Asia/CIS
Polarisation	Circular
K Band	1
Power	20W
Bandwidth	36MHz
Coverage	CIS
Polarisation	Circular

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
6	RHCP	3675	ORT-1	SECAM	7.02/7.50*

* Radio Service

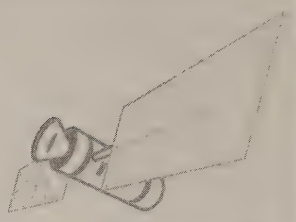




ORION 3

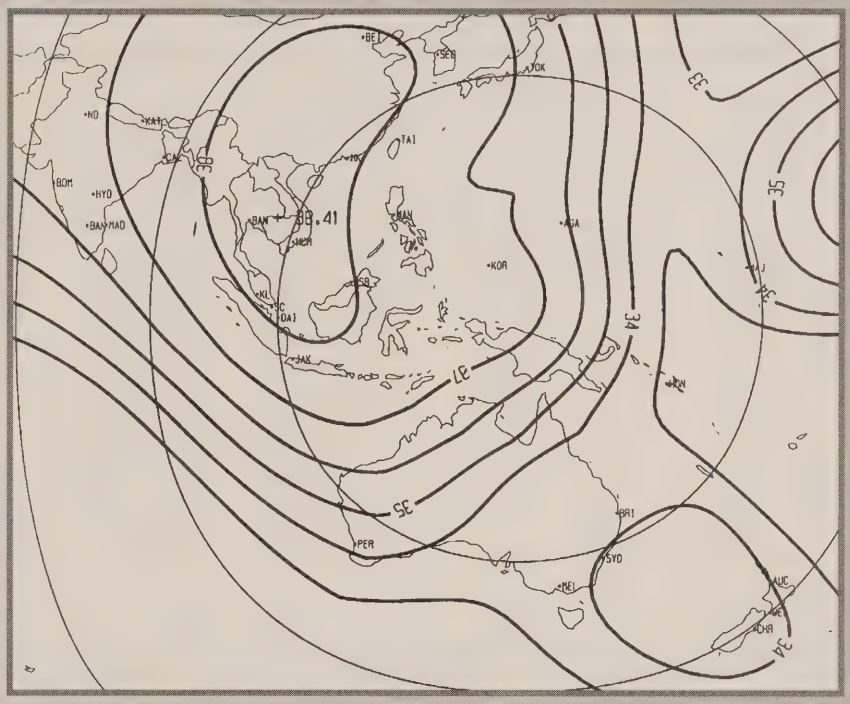
LOCATED AT 139.0 DEGREES EAST LONGITUDE

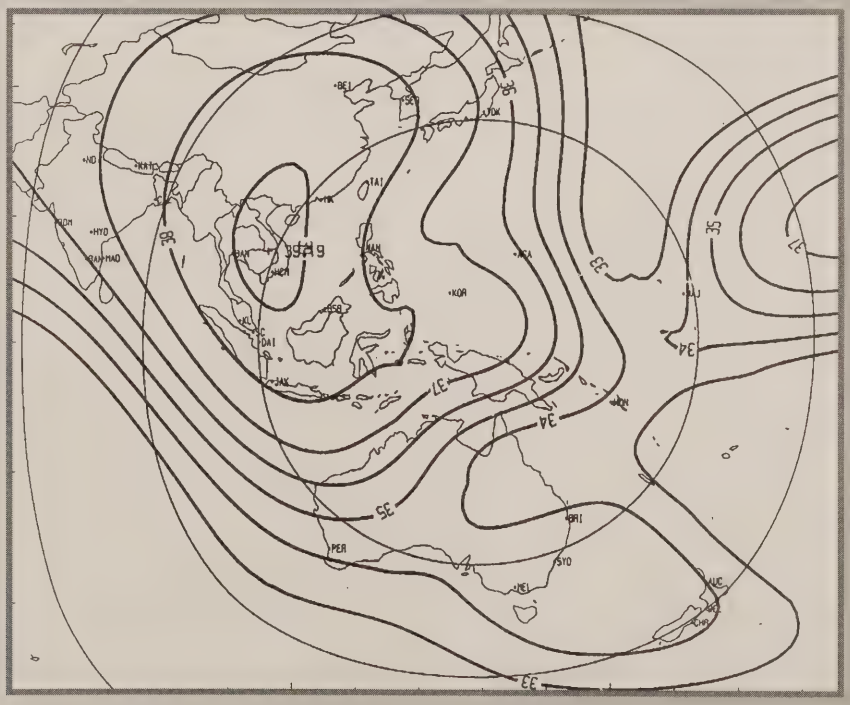
Launch Date	1st Quarter 1999	Country of Origin	USA
Launch Vehicle	Delta III	Satellite Type	HS 601 HP
Mass in Orbit	1935Kg	Stabilisation	3 Axis
Design Lifetime	13 Years		



TRANSPONDERS

C Band	10
Power	55W
Bandwidth	10 x 36MHz
Coverage	Asia/Australia
Polarisation	Linear
K Band	25
Power	115W
Bandwidth	23 x 54MHz 2 x 27 MHz 8 x 36MHz
Coverage	China, India, Japan, Australia, S.E. Asia, Oceania & Hawaii
Polarisation	Linear

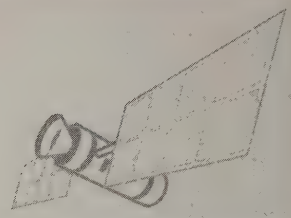




APSTAR 1

LOCATED AT 138.0 DEGREES EAST LONGITUDE

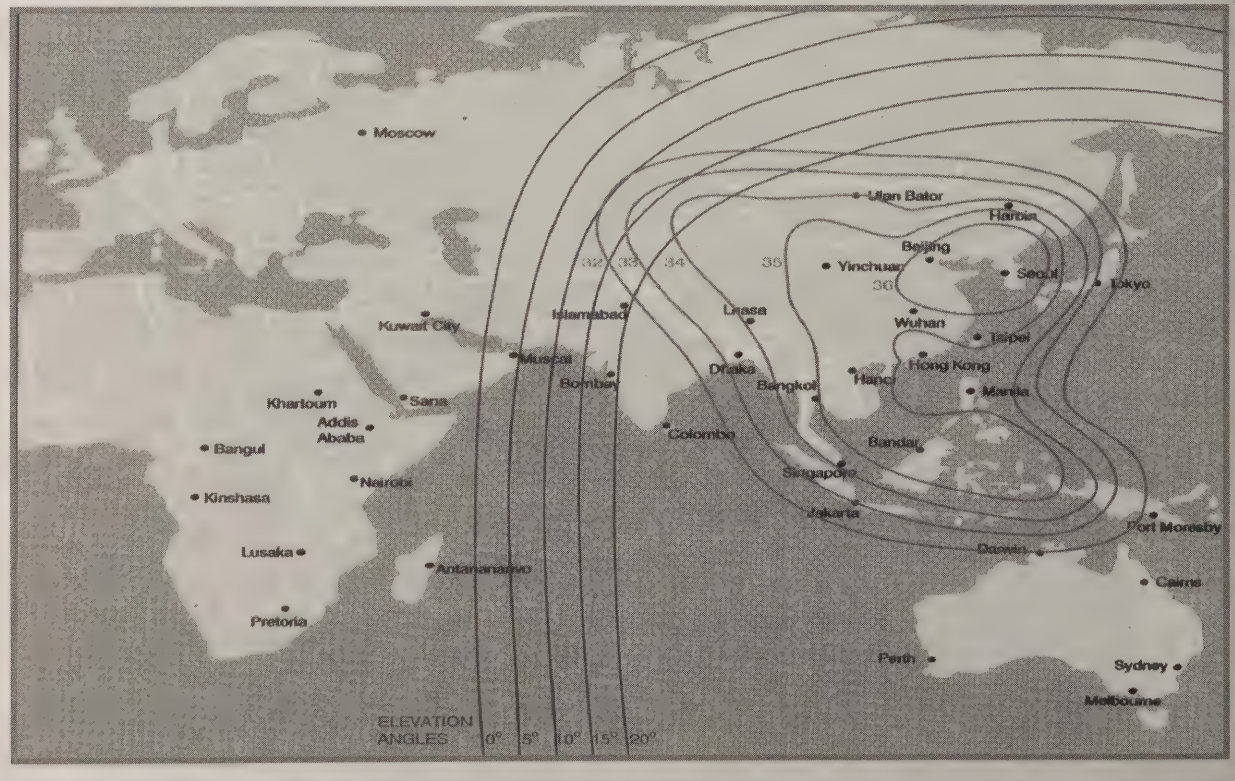
Launch Date	21/07/94	Country of Origin	Hong Kong
Launch Vehicle	Long March 3	Satellite Type	HS-376
Mass in Orbit	560Kg	Stabilisation	Spin
Design Lifetime	10 Years	US Space Command # 23185	



TRANSPONDERS

C Band	24
Backup	6
Power	16W
Bandwidth	20 x 36MHz
	4 x 72MHz
Coverage	N & SE Asia
Polarisation	Linear

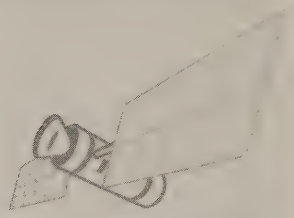
XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO
1BL	V	3636	CSTV			DIGICIPHER 1	
1B	V	3666	CSTV			DIGICIPHER 1	
1AU	H	3690	ITINERANT				
2B	V	3730	REUTERS	5632	3/4	PAL	
2B	V	3742	REUTERS	5632	3/4	PAL	
5A	H	3800	RPN 9	26700	7/8	NTSC	
4B	V	3860	MTV ASIA	30000	3/4	PAL	
5B	V	3900	SUPER CHANNEL			DIGICIPHER 1	
5B	V	3914	SPORTS CHANNEL	5680	3/4	NTSC	
7B	V	3980	CNN/TNT	26000	3/4	NTSC	
9A	H	4040	DISNEY			B-MAC CA	
9B	V	4060	HBO ASIA			CA	
10B	V	4100	ESPN INTERNATIONAL			B-MAC CA	
11B	V	4140	MTV MANDARIN			B-MAC CA	
12A	H	4160	CETV FAMILY CHANNEL			PAL	6.60
12B	V	4180	GLOBAL CHANNEL			DIGICIPHER 1	
12BU	V	4195	BBC WORLD	5800	3/4	PAL	



APSTAR 1A

LOCATED AT 134.0 DEGREES EAST LONGITUDE

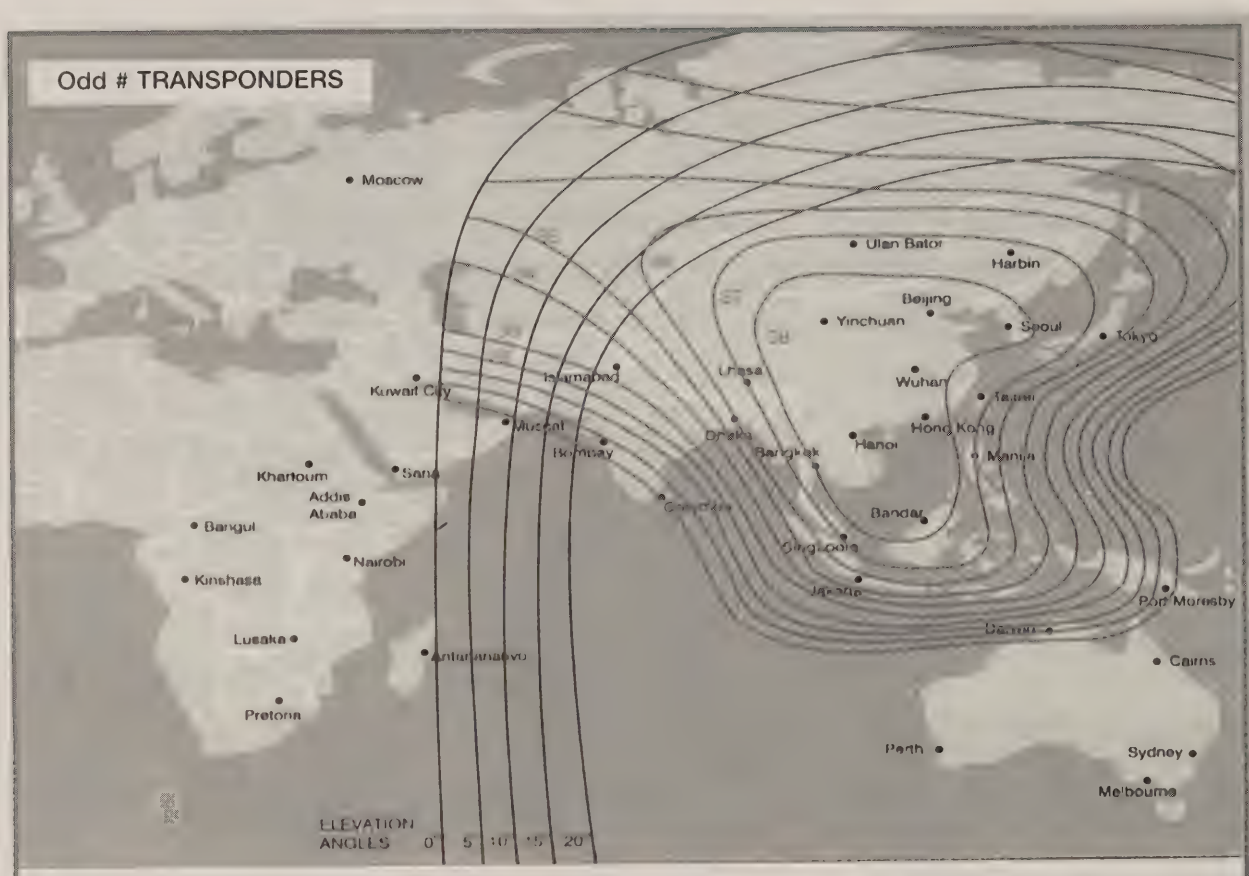
Launch Date	03/07/96	Country of Origin	Hong Kong
Launch Vehicle	Long March 3 #39	Satellite Type	HS-376
Mass in Orbit	560 Kg	Stabilisation	Spin
Design Lifetime	10 Years	US Space Command #	23943

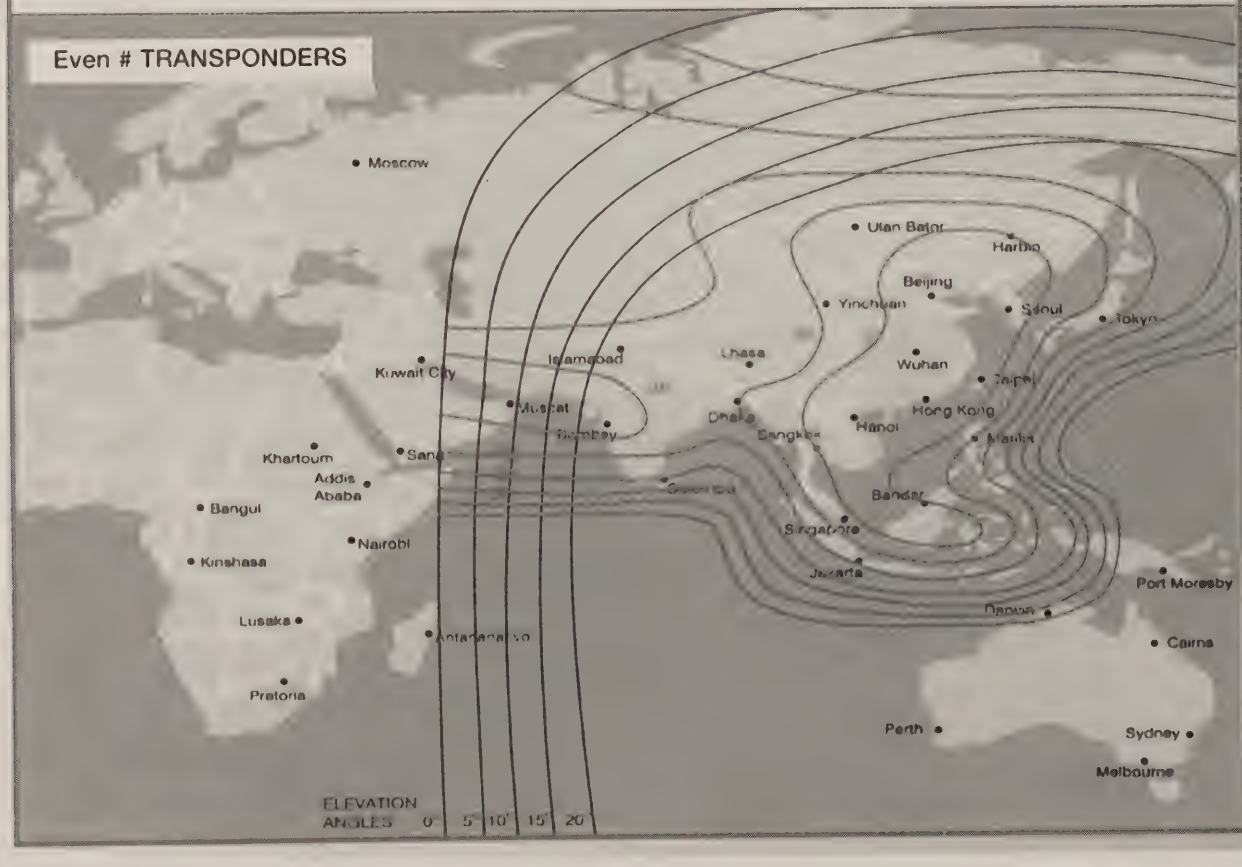


TRANSPONDERS

C Band	24
Backup	6
Power	16W
Bandwidth	20 x 36MHz
	4 x 72MHz
Coverage	India, SE Asia
Polarisation	Linear H/V

XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO
2B	V	3731	NINGXIA TV	6930	1/2	PAL	
2B	V	3789	CHONGQING TV 1	6930	1/2	PAL	
			CHONGQING RADIO 1				
3B	V	3820	CETV SD			PAL	6.60
4B	V	3860	CCTV 1			PAL	6.60
5A	H	3867	ITINERANT	6200	3/4	PAL	
5B	V	3900	CETV 2			PAL	6.60
7A	H	3960	GUIZHOU TV			PAL	6.60
7B	V	3980	CETV 1			PAL	6.60
8A	H	4000	YUNNAN TV			PAL	6.60
			YUNNAN RADIO				7.50
8B	V	4020	ZHEJIANG TV			PAL	6.60
			ZHEJIANG RADIO				8.05
9A	H	4040	XIZANG TV			PAL	6.60
			XIZANG RADIO				7.10/7.60
10A	H	4080	SICUANG TV			PAL	6.60
10B	V	4100	SHANDONG TV			PAL	6.60
11A	H	4120	XINJIANG TV	27500	3/4	PAL	
12A	H	4160	CCTV 7			PAL	6.60
12B	V	4180	CCTV 2			PAL	6.60

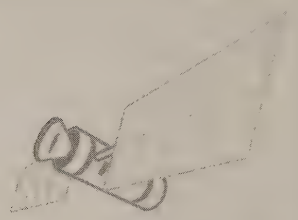

Odd # TRANSPONDERS
Moscow
Ulan Bator
Harbin
Beijing
Yinchuan
Seoul
Tokyo
Lhasa
Wuhan
Taipei
Kuwait City
Islamabad
Muscat
Dhaka
Hong Kong
Bombay
Bangkok
Hanoi
Manila
Khartoum
Sana
Addis Ababa
Bangui
Bandar
Singapore
Nairobi
Kinshasa
Jakarta
Port Moresby
Darwin
Lusaka
Antananarivo
Cairns
Pretoria
Perth
Sydney
Melbourne
ELEVATION ANGLES 0° 5° 10° 15° 20°


Even # TRANSPONDERS
Moscow
Ulan Bator
Harbin
Beijing
Yinchuan
Seoul
Tokyo
Lhasa
Wuhan
Taipei
Kuwait City
Islamabad
Muscat
Dhaka
Hong Kong
Bombay
Bangkok
Hanoi
Manila
Khartoum
Sana
Addis Ababa
Bangui
Bandar
Singapore
Nairobi
Kinshasa
Jakarta
Port Moresby
Darwin
Lusaka
Antananarivo
Cairns
Pretoria
Perth
Sydney
Melbourne
ELEVATION ANGLES 0° 5° 10° 15° 20°

JCSAT 3

LOCATED AT 128.0 DEGREES EAST LONGITUDE

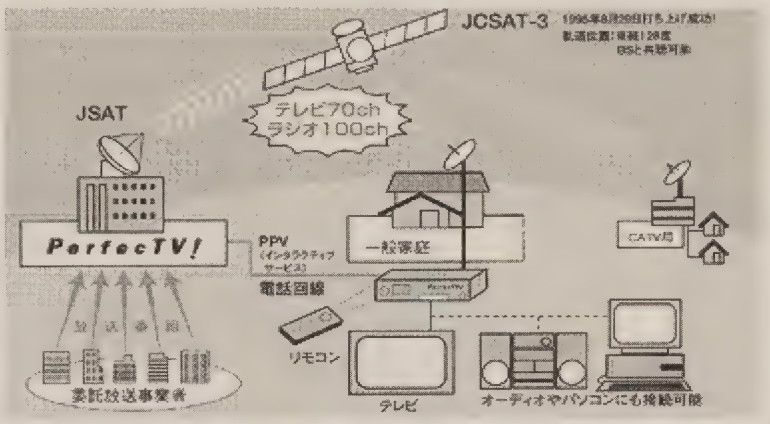
Launch Date	29/08/95	Country of Origin	Japan
Launch Vehicle	Atlas Centaur #94	Satellite Type	HS-601
Mass in Orbit	1200Kg	Stabilisation	3 Axis
Design Lifetime	12 Years	US Space Command # 23649	

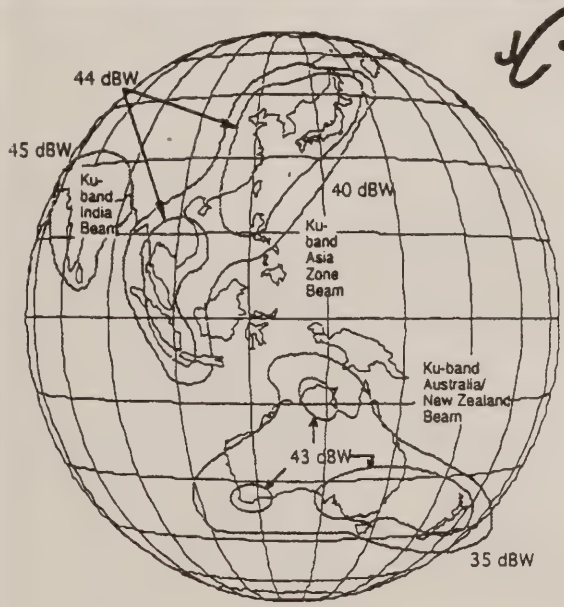


TRANSPONDERS

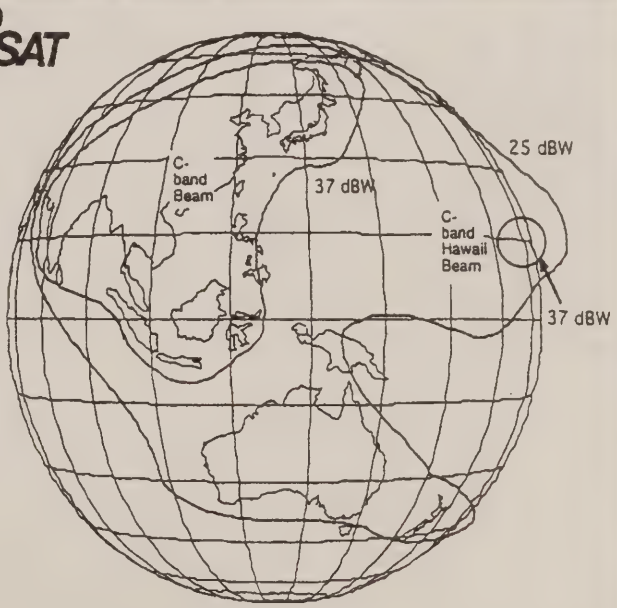
C Band	12
Backup	0
Power	34W
Bandwidth	36MHz
Coverage	Japan/Aust
Polarisation	Linear
K Band	28
Backup	0
Power	60W
Bandwidth	16 x 27MHz
	12 x 36MHz
Coverage	Japan/India
	Asia/Australia
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
2	H	3980	JCSAT TEST	NTSC	6.80
7	V	4080	JCSAT TEST	NTSC	6.80





Ku-band Service Coverage



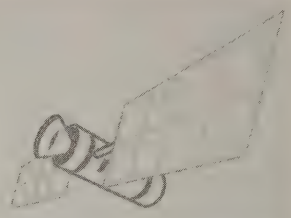
C-band Service Coverage

Source: Japan Satellite Systems Inc.

GORIZONT 30
also known as ASIASAT G

LOCATED AT 122 DEGREES EAST LONGITUDE

Launch Date	20/05/94	Country of Origin	CIS
Launch Vehicle	Proton #223	Satellite Type	NPO PM
Mass in Orbit	2120 Kg	Stabilisation	3 Axis
Design Lifetime	3-5 Years	US Space Command #	23108



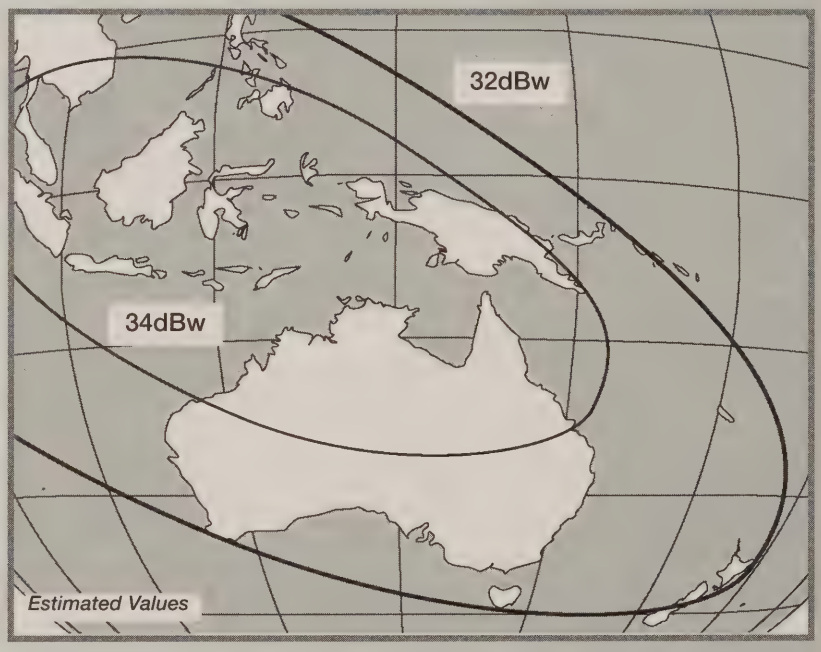
TRANSPONDERS

C Band	6
Backup	1
Power	65W
Bandwidth	5 x 36MHz
	1 x 40MHz
Coverage	Asia/Pacific
Polarisation	Circular
K Band	1
Backup	0
Power	65W
Bandwidth	36MHz
Coverage	CIS
Polarisation	Circular

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
6	LHCP	3675	NTV	SECAM	7.00

HISTORY

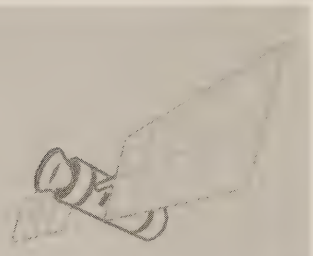
To be replaced by ASIASAT 1
(105.5E) 1999



PALAPA B4

LOCATED AT 118.0 DEGREES EAST LONGITUDE

Launch Date	14/05/92	Country of Origin	Indonesia
Launch Vehicle	Delta 2 # 209	Satellite Type	HS 376
Mass in Orbit	628Kg	Stabilisation	Spin
Design Lifetime	8 Years	US Space Command #	21964

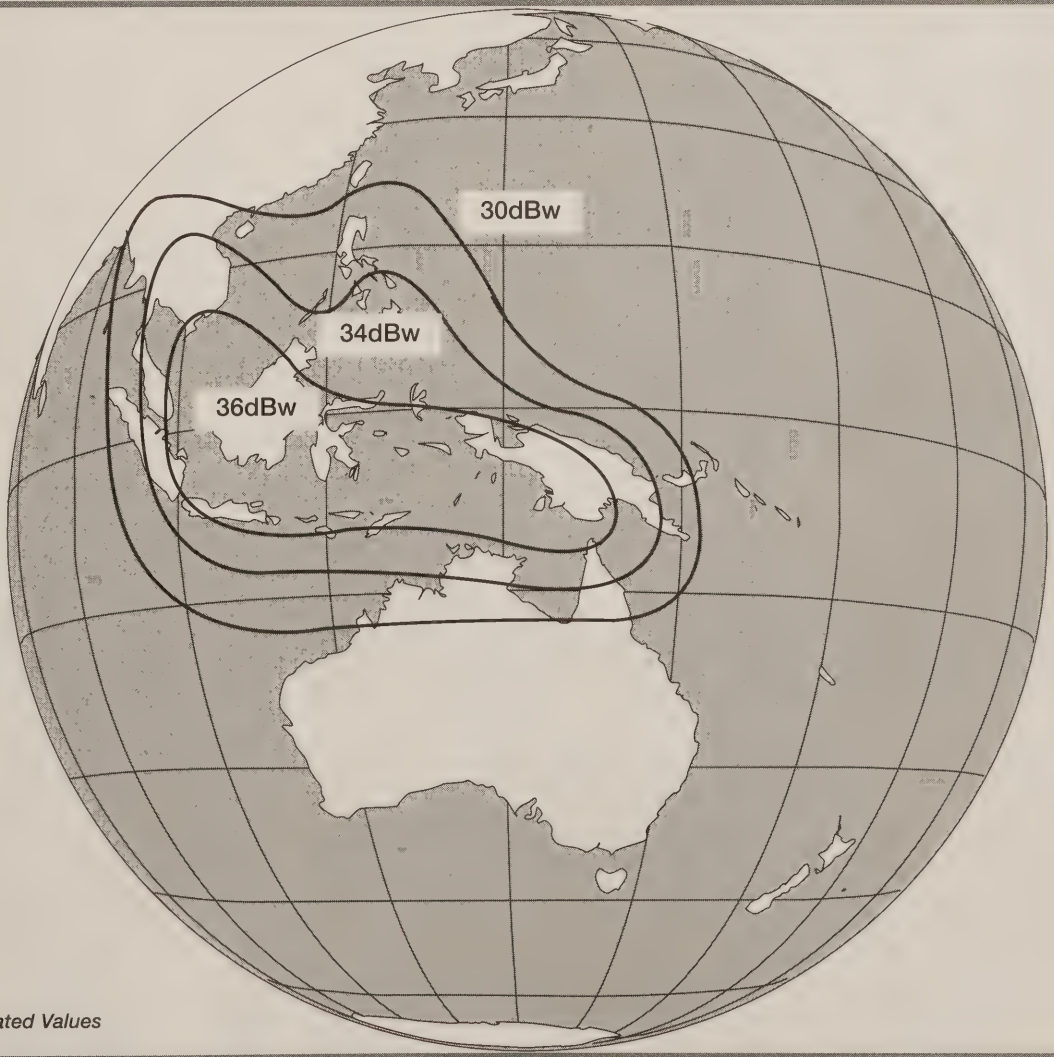


TRANSPONDERS

C Band	24
Backup	6
Power	10W
Bandwidth	36MHz
Coverage	Indonesia
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO

No video transmission observed.

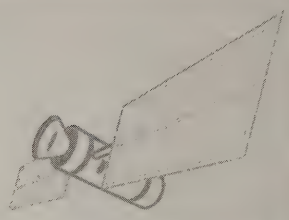


Estimated Values

PALAPA C2

LOCATED AT 113.0 DEGREES EAST LONGITUDE

Launch Date	16/05/96	Country of Origin	Indonesia
Launch Vehicle	Ariane V86	Satellite Type	HS 601
Mass in Orbit	1800Kg	Stabilisation	3 Axis
Design Lifetime	14 Years	US Space Command #	23864

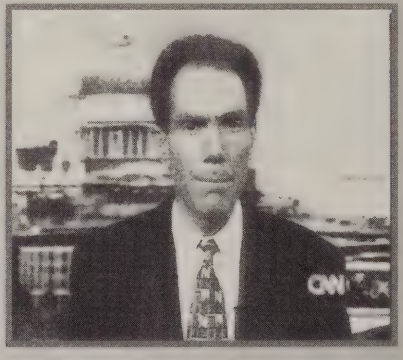


TRANSPONDERS

C Band	30
Backup	8
Power	21.5/26.5W
Bandwidth	36MHz
Coverage	Indonesia/Asia Australia/PNG/NZ
Polarisation	Linear
K Band	4
Backup	2
Power	130W
Bandwidth	72MHz
Coverage	Indonesia/H.Kong
Polarisation	Linear

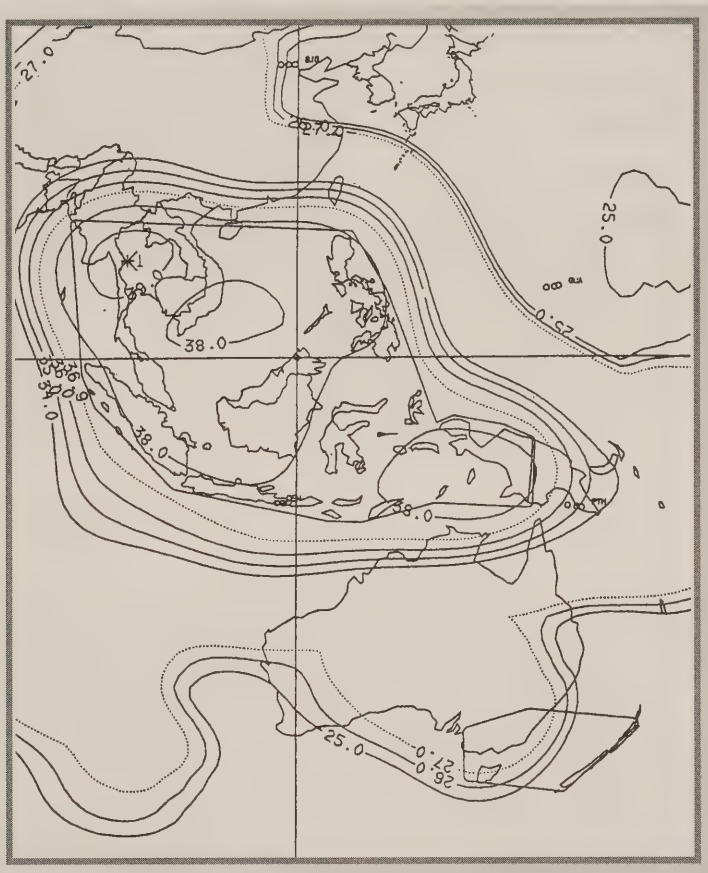
XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
3EH	H	3500	INDOVISION	CA	
1V	V	3740	RCTI	PAL	6.6/7.2/7.9
2V	V	3780	INDOVISION	CA	
3H	H	3800	GUJARAT TV	PAL	6.8
3V	V	3820	TPI SR 26665 FEC 3/4	PAL	
4H	H	3840	TVRI	PAL	6.20/6.80
4V	V	3860	MTV SR 6198 FEC 3/4	PAL	
5H	H	3880	AUSTRALIA TV	PAL	6.8
5V	V	3900	TV3	PAL	6.8
7H	H	3960	SCTV	PAL	6.6/7.2
7V	V	3980	CNN	PAL	6.8/6.3*
8H	H	4000	HBO ASIA	B-MAC	
9H	H	4040	CNBC ASIA	PAL	6.8
9V	V	4060	INDOSIAR	PAL	6.6/6.8/7.0
10H	H	4080	HERBALIFE	PAL	6.2/6.8
11H	H	4120	MTV Asia	PAL	6.8/7.56/7.74
11V	V	4140	BRUNEI TV	PAL	6.8
12H	H	4160	TV5 ASIA	PAL	5.8/6.6
			RFI RADIO		7.2/8.0
12V	V	4180	TPI	PAL	6.60

* Radio Service.

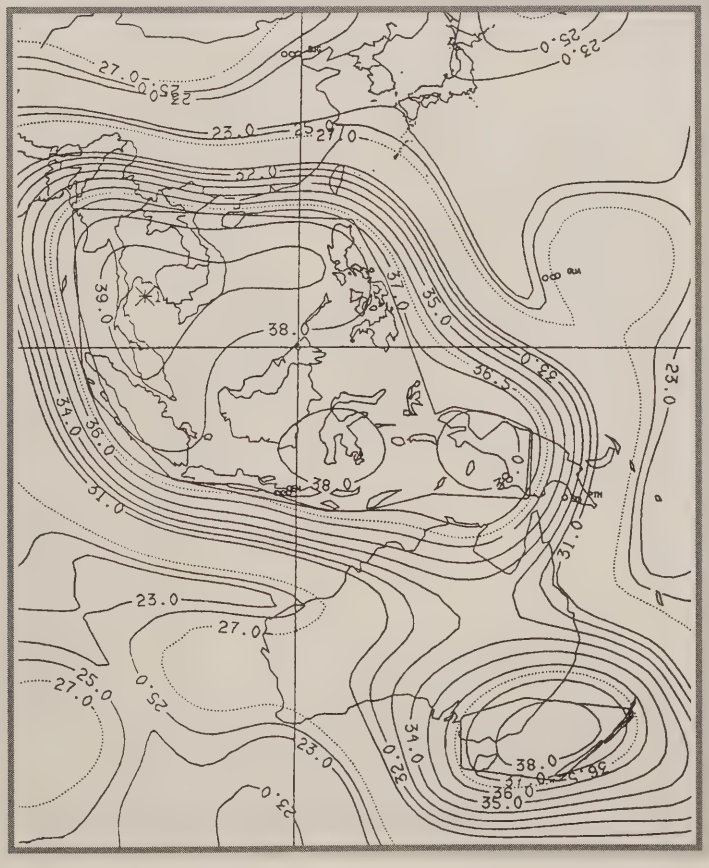


PALAPA C2

LOCATED AT 113.0 DEGREES EAST LONGITUDE



ASEAN BEAM



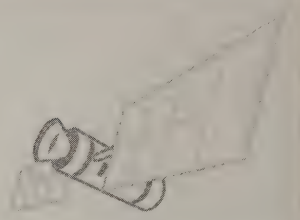
ASEAN & NZ BEAM

Original Source: Hughes/Satellindo

PALAPA B2R

LOCATED AT 108.0 DEGREES EAST LONGITUDE

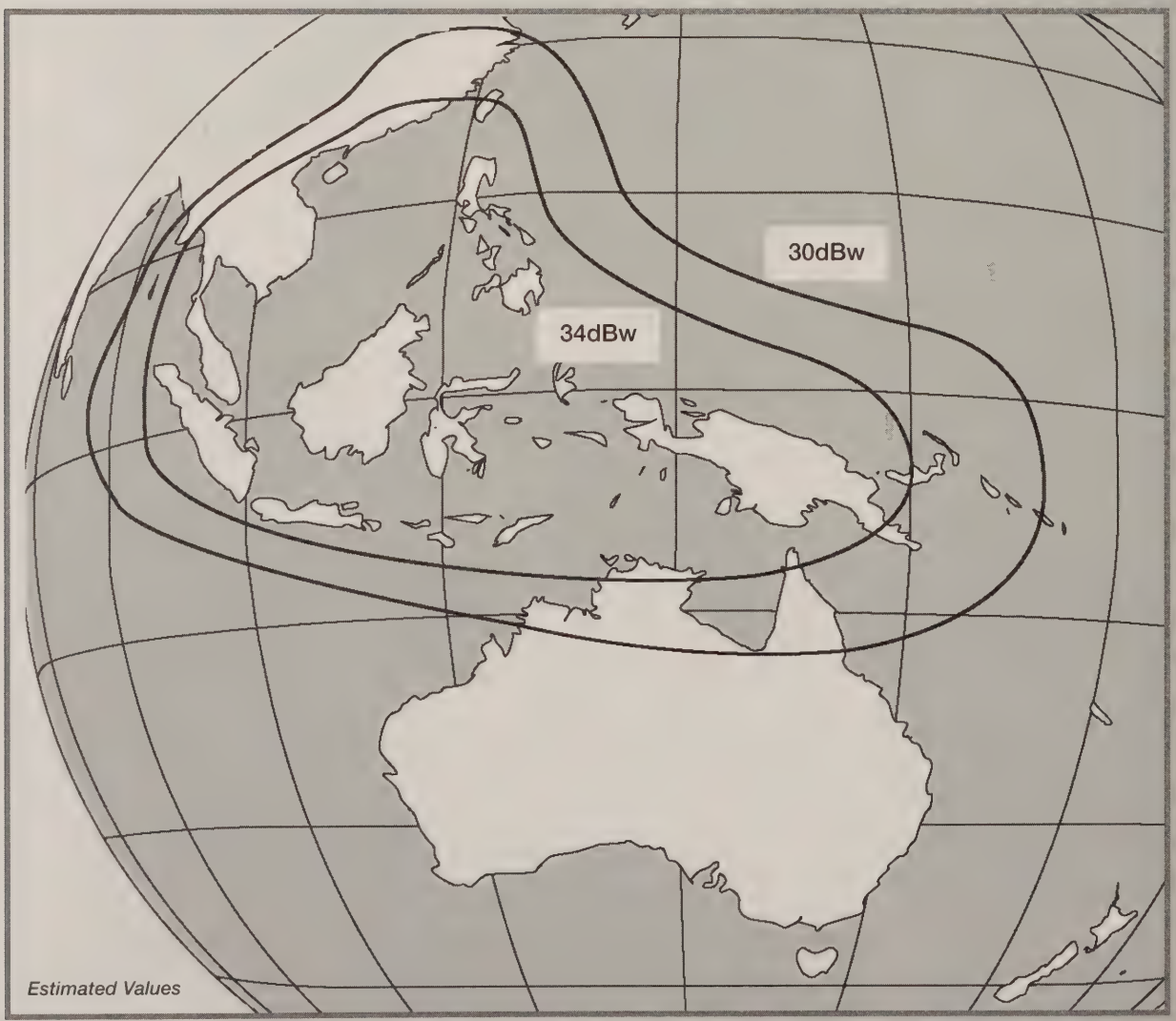
Launch Date	13/01/90	Country of Origin	Indonesia
Launch Vehicle	Delta 2 #194	Satellite Type	HS 376
Mass in Orbit	628Kg	Stabilisation	Spin
Design Lifetime	8 Years	US Space Command # 20570	



TRANSPONDERS

C Band	24
Backup	6
Power	10W
Bandwidth	36MHz
Coverage	Indonesia/PNG/N.Australia
Polarisation	Linear

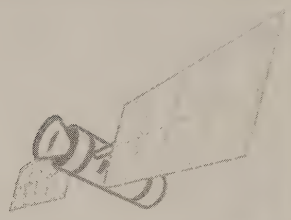
XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
	H	3840	TVRI FEEDS	PAL	6.80
	H	4000	TVRI FEEDS	PAL	6.80
	H	4160	TVRI FEEDS	PAL	6.80



CAKRAWARTA 1

LOCATED AT 107.7 DEGREES EAST LONGITUDE

Launch Date	12/11/97	Country of Origin	Indonesia
Launch Vehicle	Ariane V102	Satellite Type	STARbus
Mass in Orbit	802Kg	Stabilisation	Spin
Design Lifetime	10 Years	US Space Command #	25050

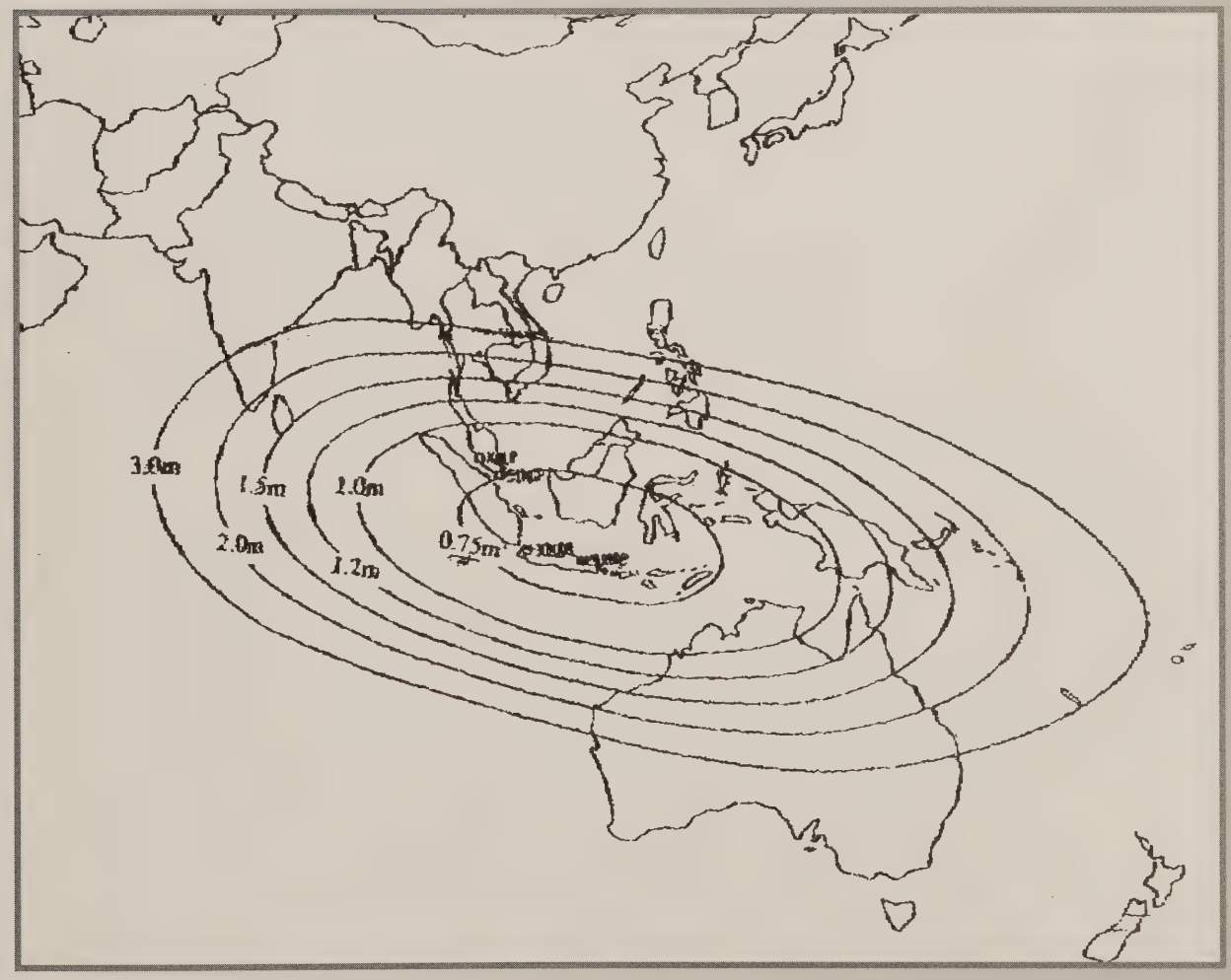


TRANSPONDERS

S Band	5
Power	70W
Bandwidth	5 x 27MHz
Coverage	Indonesia/Australia
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
	H	2540	INDOVISION SR20000 FEC 5/6 PAL CA		

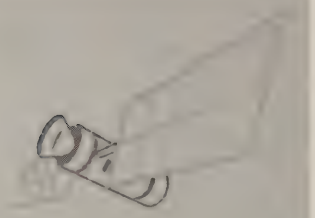
Power supply damaged by solar storm reducing transponder power.



ASIASAT 3S

LOCATED AT 105.5 DEGREES EAST LONGITUDE

Launch Date	First Quarter 1999	Country of Origin	Hong Kong
Launch Vehicle	Proton	Satellite Type	HS 601HP
Mass in Orbit	1500Kg	Stabilisation	3 Axis
Design Lifetime	15 Years		



TRANSPONDERS

C Band	24
Backup	6
Power	55W
Bandwidth	20 x 36MHz
	4 x 72MHz
Coverage	Asia/Australia
Polarisation	Linear
K Band	9
Backup	0
Power	115W
Bandwidth	54
Coverage	China
Polarisation	Linear

HISTORY

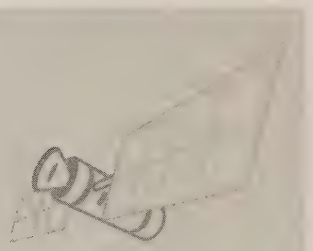
To be replaced by ASIASAT 1

ASIASAT 1 will move to 122E

GORIZONT 25

LOCATED AT 103.0 DEGREES EAST LONGITUDE

Launch Date	02/04/92	Country of Origin	CIS
Launch Vehicle	Proton #206	Satellite Type	NPO Gorizont
Mass in Orbit	2120Kg	Stabilisation	3 Axis
Design Lifetime	3-5 Years	US Space Command #	21922



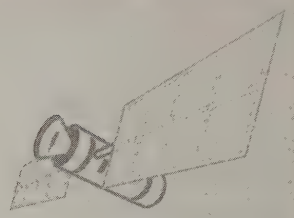
TRANSPONDERS

C Band	6
Power	1 x 40W
	5 x 15W
Bandwidth	5 x 36MHz
	1 x 40MHz
Coverage	IOR to E.Australia
Polarisation	RHCP

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
6	RHCP	3675	RTR (Orbital)	SECAM	7.02/7.5*

*Radio Service

Launch Date	28/11/95	Country of Origin	Hong Kong
Launch Vehicle	Long March 2E	Satellite Type	GE 7000
Mass in Orbit	1500Kg	Stabilisation	3 Axis
Design Lifetime	15 Years	US Space Command #	23723



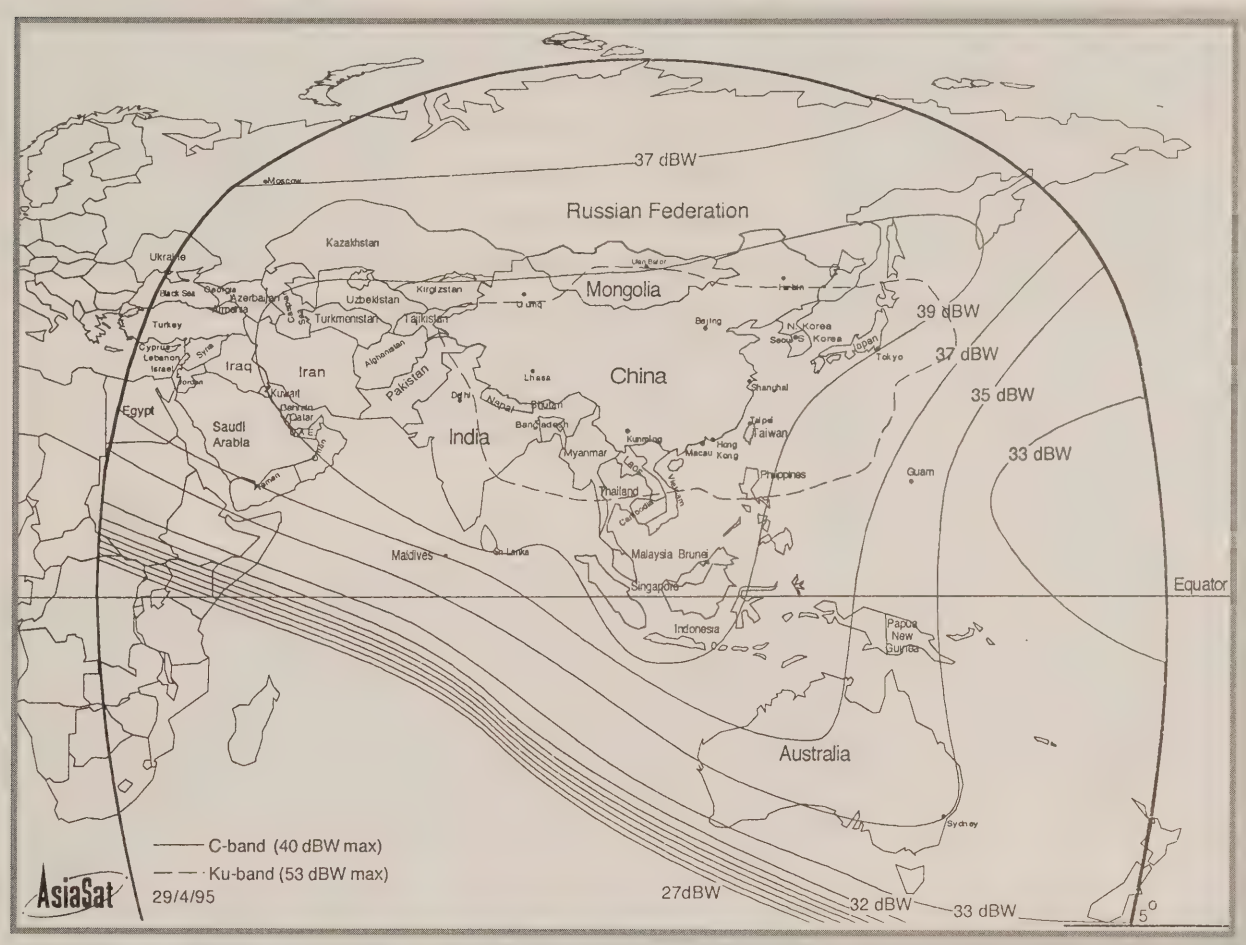
TRANSPONDERS

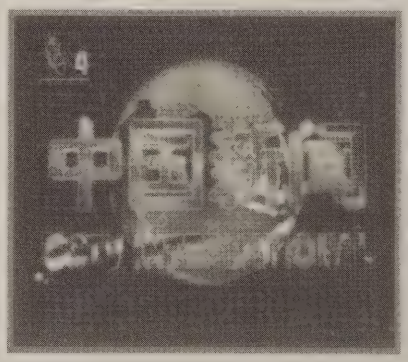
C Band	24
Backup	6
Power	55W
Bandwidth	20 x 36MHz
	4 x 72MHz
Coverage	Asia/Australia
Polarisation	Linear
K Band	9
Backup	0
Power	115W
Bandwidth	54
Coverage	China
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO
1B	H	3670	RTE			PAL	6.60
			EGYPTIAN RADIO				7.20/7.56
3B	H	3706	HENAN TV	4418	3/4	PAL	
3B	H	3713	QINGHAI TV	4418	3/4	PAL	
3B	H	3720	FUJIAN TV	4418	3/4	PAL	
3B	H	3727	JIANGXI TV	4418	3/4	PAL	
3B	H	3734	LIAONING TV	4418	3/4	PAL	
4A	V	3766	MYAWADY TV	5080	7/8	NTSC	
4B	V	3795	FASHION TV	2533	3/4	PAL	
5B	H	3800	APTV	5632	3/4	PAL	
5A	V	3806	GXTV	4418	3/4	PAL	
5A	V	3813	SHAANXI TV	4418	3/4	PAL	
5A	V	3820	AHTV	4418	3/4	PAL	
5A	V	3827	JSTV	4418	3/4	PAL	
6B	H	3830	NMTV2	8398	3/4	PAL	
5A	V	3834	HEI LONG JIANG TV	4418	3/4	PAL	
6B	H	3840	GD TV1	4418	3/4	PAL	
6B	H	3847	HUNAN TV	4418	3/4	PAL	
6B	H	3854	HUBEI TV	4418	3/4	PAL	
7B	H	3880	WORLDNET			PAL	6.60
			VOICE OF AMERICA				7.02/7.20
			VOA/RFE				7.38/7.56
8A	V	3940	KIBC	26650	2/3	PAL	
9B	H	3960	CCTV4			PAL	6.65
9A	V	3980	RTPi			PAL	6.60
			RTP INTERNATIONAL				7.20
10B	H	4000	DEUTSCHE WELLE	28125	3/4	PAL	
10B	H	4000	MCM				
10B	H	4000	RAI INTERNATIONAL				
10B	H	4000	TVE INTERNATIONAL				
10B	H	4000	TV5 ASIA				
12B	H	4143	LAO TV CH3	2889	3/4	PAL	
RADIO							
10B	H	4000	REE				
10B	H	4000	RFI				
10B	H	4000	RFI ASIA				
10B	H	4000	RAI INTERNATIONAL				
10B	H	4000	DW1				
10B	H	4000	DW2 + DW3				
10B	H	4000	DW4 + DW5				
10B	H	4000	YLE + RCI				
10B	H	4000	WRN				
10B	H	4000	NNR + SRI				
10B	H	4000	RFI				

ASIASAT 2

LOCATED AT 100.5 DEGREES EAST LONGITUDE

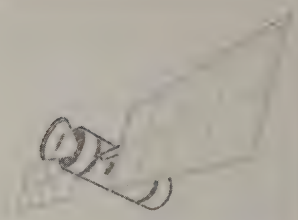




GORIZONT 27

LOCATED AT 96.5 DEGREES EAST LONGITUDE

Launch Date	27/11/92	Country of Origin	CIS
Launch Vehicle	Proton #211	Satellite Type	NPO Gorizont
Mass in Orbit	2120Kg	Stabilisation	3 Axis
Design Lifetime	3-5 Years	US Space Command # 22245	

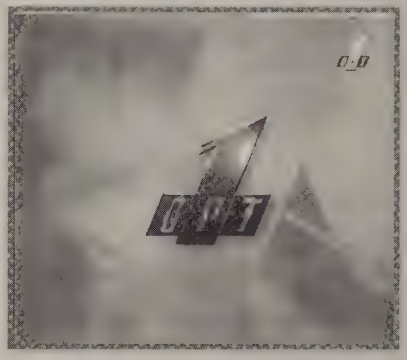


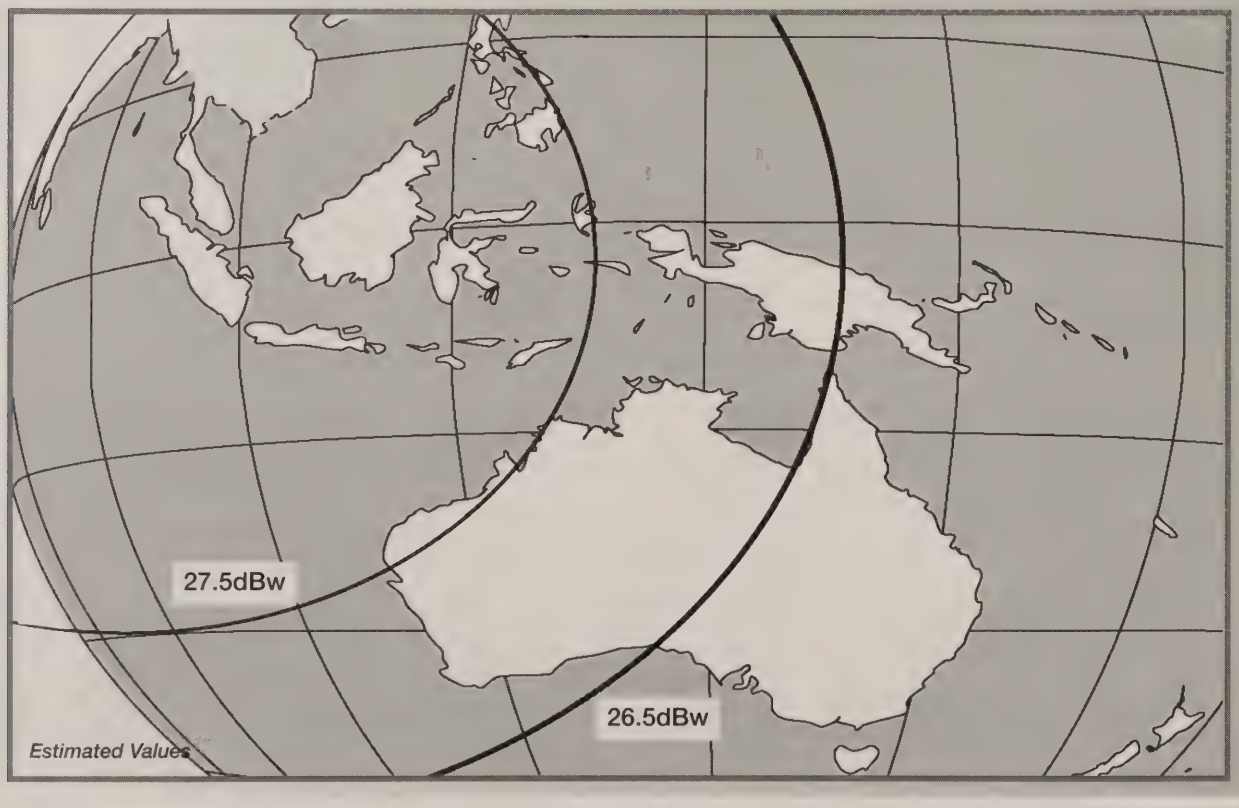
TRANSPONDERS

C Band	6
Power	1 x 40W
	5 x 15W
Bandwidth	1 x 40MHz
	5 x 36MHz
Coverage	IOR/W.Australia
Polarisation	RHCP
K Band	1
Power	20W
Bandwidth	36MHz
Coverage	IOR
Polarisation	RHCP

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
6	RHCP	3675	ORT-1	SECAM	7.02/7.50*

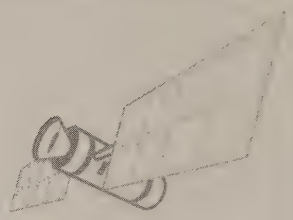
* Radio Service





Insat 2C

Launch Date	6/12/95	Country of Origin	India
Launch Vehicle	Ariane V81	Satellite Type	Insat 2
Mass in Orbit	1100Kg	Stabilisation	3 Axis
Design Lifetime	10 Years	US Space Command #	23731



Insat 2B

Launch Date	22/7/93	Country of Origin	India
Launch Vehicle	Ariane V58	Satellite Type	Insat 2
Mass in Orbit	1162Kg	Stabilisation	3 Axis
Design Lifetime	7 Years	US Space Command #	22724

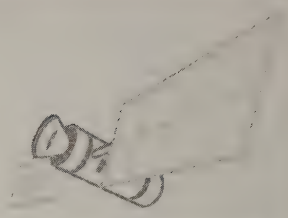
TRANSPONDERS

C Band	18
Power	4.5W
Bandwidth	18 x 36MHz
Coverage	India
Polarisation	Linear

S Band	3
Power	50W
Bandwidth	36
Coverage	India
Polarisation	LHCP

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
11	H	4125	DD 1 National	PAL	5.50/5.80
12	H	4165	DD 2 Metro	PAL	5.50

Launch Date	12/01/96	Country of Origin	Malaysia
Launch Vehicle	Ariane V89	Satellite Type	HS 376E
Mass in Orbit	650Kg	Stabilisation	Spin
Design Lifetime	12 Years	US Space Command #	23765



TRANSPONDERS	
C Band	12
Power	12W
Bandwidth	36MHz
Coverage	Malaysia/Philipines/S.India
Polarisation	Linear
K Band	4
Power	112W
Bandwidth	54MHz
Coverage	Malaysia/Philipines/S.India
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
	H	3710	VTV	PAL	6.50
	H	3880	RTM TV 1	PAL	6.60
			RTM RADIO 1		5.40
			RTM RADIO MUZIK		5.80
			RTM RADIO 4		6.20
			RTM RADIO KUCHING		7.00
			RTM RADIO 5		7.40
			VOICE OF MALAYSIA		7.80

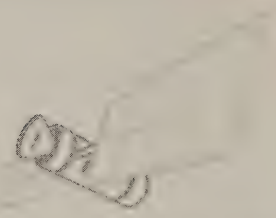
C-Band footprint over Malaysia, Singapore, Brunei, Indonesia, Vietnam, Myanmar, Taiwan, Hong Kong, Southern China, Philippines, Northern Australia, Cambodia, Laos, Thailand, Korea, Guam and Japan

Original Source: Measat

GORIZONT 28

LOCATED AT 90.0 DEGREES EAST LONGITUDE

Launch Date	28/10/93	Country of Origin	CIS
Launch Vehicle	Proton #217	Satellite Type	NPO Gorizont
Mass in Orbit	2120Kg	Stabilisation	3 Axis
Design Lifetime	3-5 Years	US Space command	#22880



TRANSPONDERS

C Band	6
Power	1 x 40W
	5 x 15W
Bandwidth	1 x 40MHz
	5 x 36MHz
Coverage	IOR/E.Australia
Polarisation	RHCP
K Band	1
Power	20W
Bandwidth	36MHz
Coverage	IOR
Polarisation	RHCP

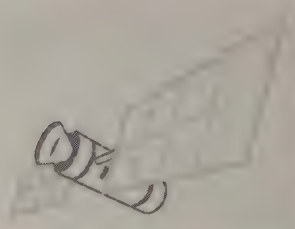
XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
6	RHCP	3675	RTR	SECAM	7.02/7.50*

*Radio Service.

RADUGA 30 (STATSIONAR 03)

LOCATED AT 85.0 DEGREES EAST LONGITUDE

Launch Date	30/09/93	Country of Origin	CIS
Launch Vehicle	Proton # 216	Satellite Type	Raduga
Mass in Orbit	1965Kg	Stabilisation	3 Axis
Design Lifetime	3-5 Years	US Space Command #	22836



TRANSPONDERS

C Band	3
Power	15W
Bandwidth	36MHz
Coverage	IOR
Polarisation	RHCP

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
6	LHCP	3600	ITINERANT	SECAM	7.02/7.50*

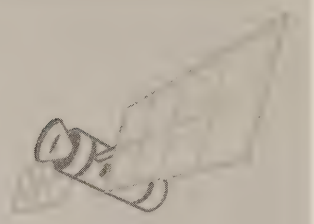
* Radio Service

Note: Signal observable on Australian east coast.

INTELSAT APR-1

LOCATED AT 83 DEGREES EAST LONGITUDE

Launch Date	1999	Country of Origin	International
Launch Vehicle		Satellite Type	
Mass in Orbit		Stabilisation	
Design Lifetime			



TRANSPONDERS

C Band	9
Power	xxxx
Bandwidth	2 x 36MHz
	2 x 72MHz
	5 x 36MHz(Zone)
Coverage	Asia/Australia
Polarisation	Linear

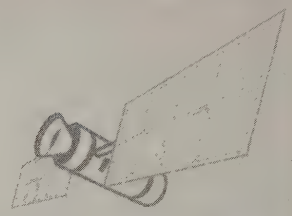
FUTURE PLANNED SPACECRAFT

Original Source: Intelsat www

GORIZONT 24

LOCATED AT 80.0 DEGREES EAST LONGITUDE

Launch Date	23/10/91	Country of Origin	CIS
Launch Vehicle	Proton #202	Satellite Type	NPO Gorizont
Mass in Orbit	2120Kg	Stabilisation	3 Axis
Design Lifetime	3-5 Years	US Space Command #	21759

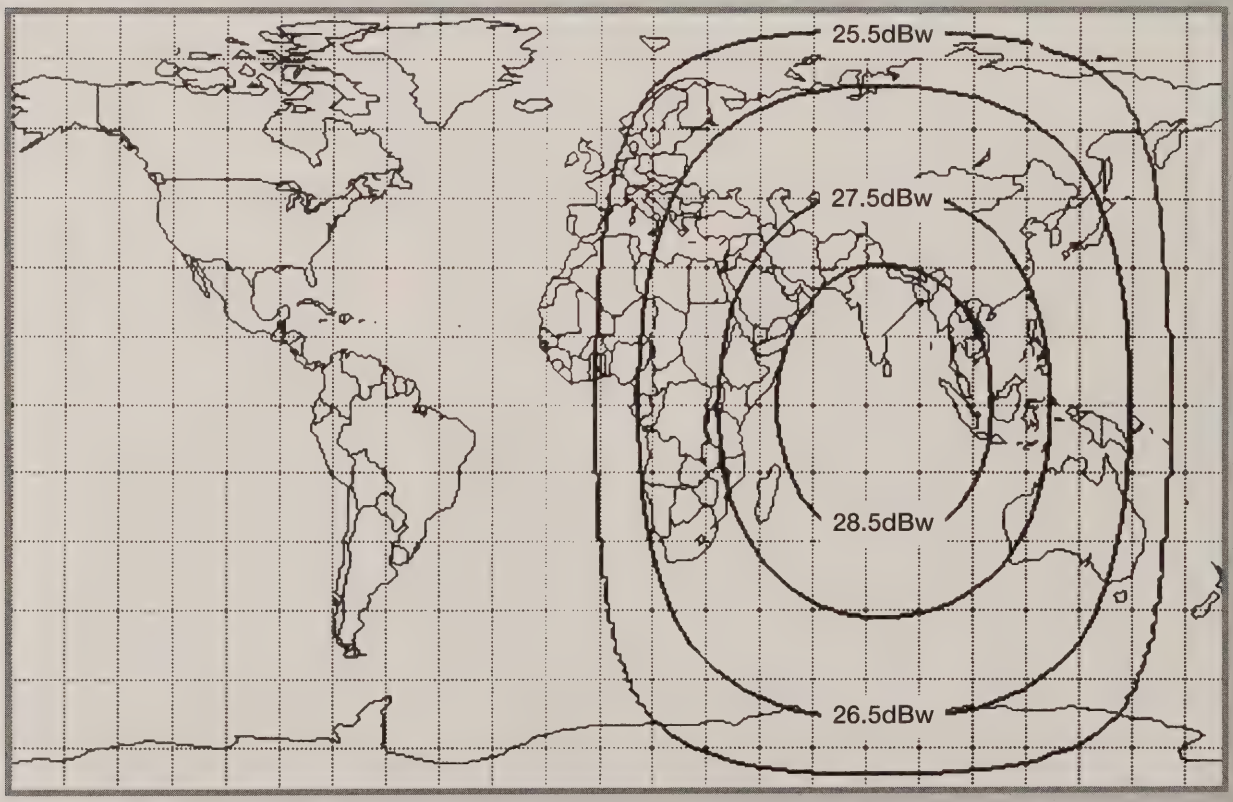


TRANSPONDERS

C Band	6
Power	1 x 40W
	5 x 36W
Bandwidth	1 x 40MHz
	5 x 36MHz
Coverage	IOR/E.Australia
Polarisation	RHCP
K Band	1
Power	20W
Bandwidth	36MHz
Coverage	CIS
Polarisation	Circular

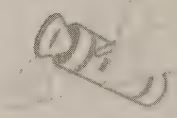
XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
T6	RHCP	3675	RTR	SECAM	7.02/7.50*
			MART	PAL	7.02
10	RHCP	3875	VTV 4 Vietnam	SECAM	7.50
			TV 6 Moscow	PAL	7.50
			2 x 2	PAL	7.50

* Radio Service.



Source: Intersputnik Users Handbook

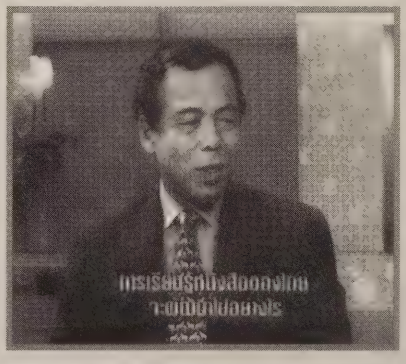
Launch Date	16/4/97	Country of Origin	Thailand
Launch Vehicle	Ariane V95	Satellite Type	Spacebus 3000A
Mass in Orbit	2150Kg	Stabilisation	3 Axis
Design Lifetime	14 Years	US Space Command #	24768

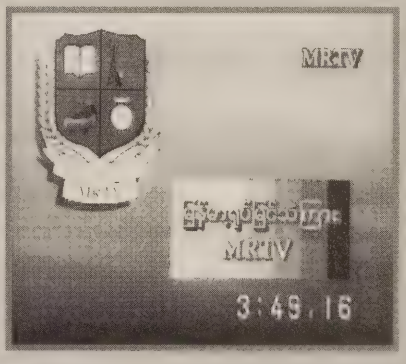


TRANSPONDERS

C Band	25
Backup	2
Power	11W
Bandwidth	10 x 36MHz
Coverage	Asia/Australia/Europe/Africa/ India/Thailand/Indo China
Polarisation	Linear
K Band	14
Backup	0
Power	115W
Bandwidth	54
Coverage	XXX
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO
5G	H	3600	THAI TV 5	26662	3/4	PAL	
			MAHARISHI VEDA VIS	26662	3/4	PAL	
			THAICOM TEST	26662	3/4	PAL	
6GU	H	3649	VTV			PAL	6.6/7.02
7G	H	3680	MYANMAR TV			NTSC	6.60

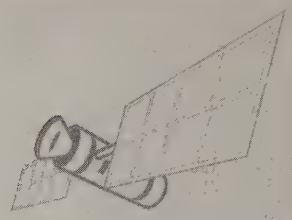




APSTAR 2R

LOCATED AT 76.5 DEGREES EAST LONGITUDE

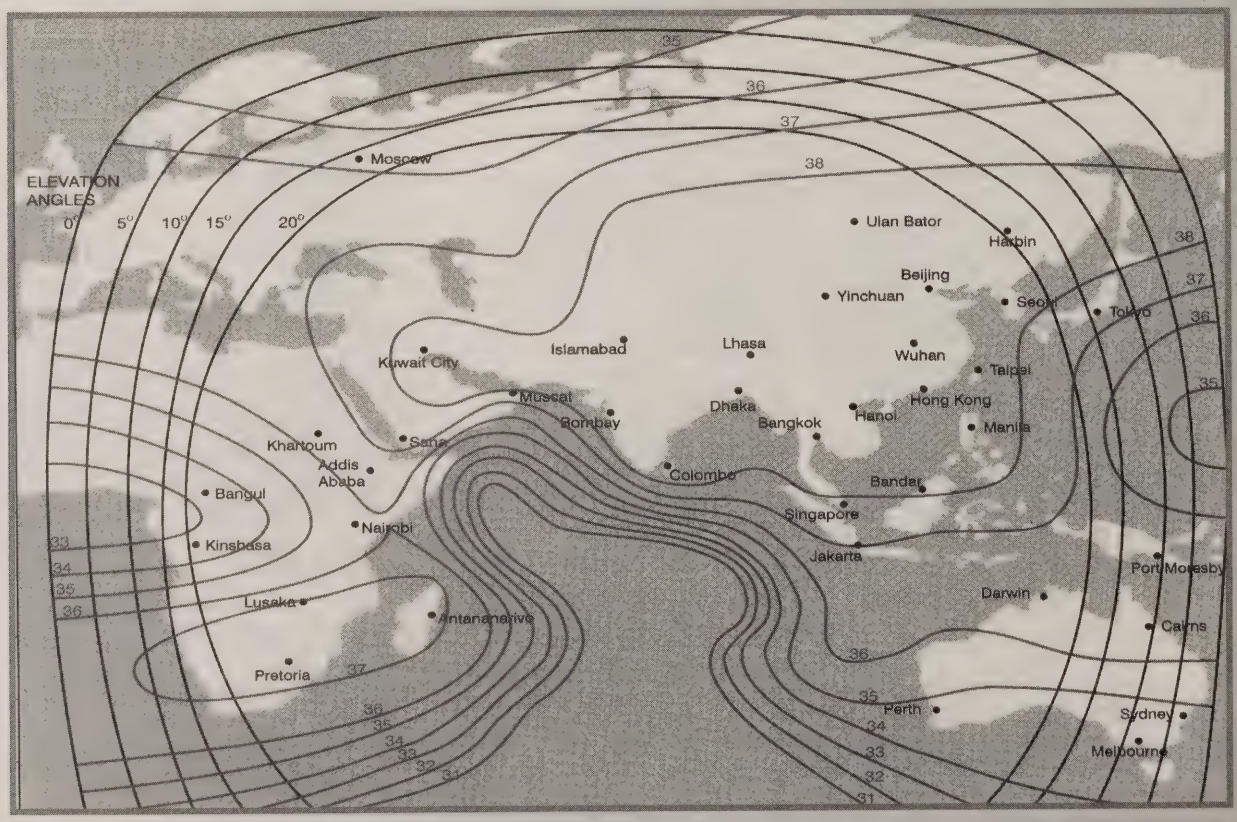
Launch Date	1997	Country of Origin	China
Launch Vehicle	Long March 3B	Satellite Type	FS 1300
Mass in Orbit	1415Kg	Stabilisation	3 Axis
Design Lifetime	15 Years	US Space Command # 25010	



TRANSPONDERS

C Band	28
Power	60W
Bandwidth	1 x 30MHz
	27 x 36MHz
Coverage	Asia/Australia
	Part of Europe
Polarisation	Linear
K Band	16
Power	110W
Bandwidth	15 x 54MHz
	1 x 36MHz
Coverage	China
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO
3A	H	3720	HALLMARK	19057	3/4	PAL CA	
7A	H	3880	DISNEY	28125	5/6	PAL CA	
8A	H	3920	AXN	28340	7/8	NTSC CA	

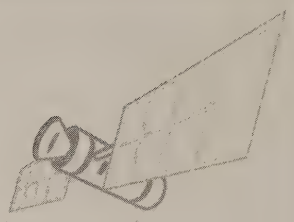


Source: APT Satellite Company Ltd

INTELSAT 505

LOCATED AT 72.0 DEGREES EAST LONGITUDE

Launch Date	28/9/82	Country of Origin	International
Launch Vehicle	Atlas Centaur	Satellite Type	Intelsat 5
Mass in Orbit	1040Kg	Stabilisation	3 Axis
Design Lifetime	7 Years	US Space command #	13595



TRANSPONDERS

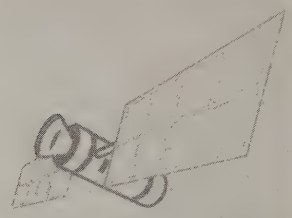
C Band	21
Power	8.5/4.5W
Bandwidth	20 x 36MHz
	1 x 72MHz
Coverage	See footprint
Polarisation	Linear
K Band	6
Backup	4
Power	10W
Bandwidth	2 x 72MHz
	2 x 241MHz
Coverage	See footprint
Polarisation	Linear

History

Jan 1991 63°E Inclined
Feb 1992 66°E Inclined
Nov 1994 65°E Inclined
Aug 1996 33°E Inclined
Apr 1997 72°E Inclined

Original Source: Intelsat www

Launch Date	03/08/95	Country of Origin	USA
Launch Vehicle	Ariane V76	Satellite Type	HS 601
Mass at Launch	2920Kg	Stabilisation	3 Axis
Design Lifetime	15 Years	US Space command #	23636

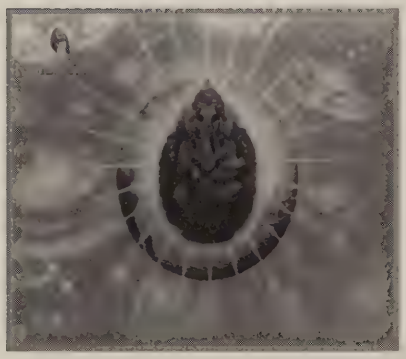


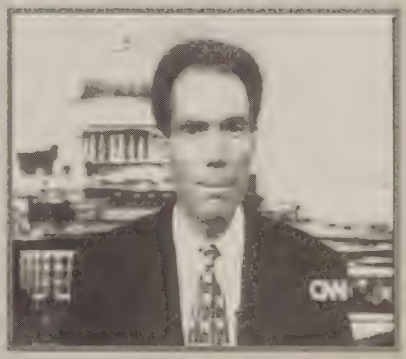
TRANSPONDERS

C Band	16
Power	30W
Bandwidth	12 x 54MHz
	4 x 64MHz
Coverage	Europe, Africa
	S.E.Asia, Sing'pre
	W.Aust. & S.China
Polarisation	Linear
K Band	24
Power	60W
Bandwidth	16 x 27MHz
	6 x 54MHz
	2 x 64MHz
Coverage	Europe, M.East, India
	S.Africa, Indonesia
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO
3	H	3785	TEST			PAL	6.80
8L	V	3910	MAHARISHI V V			PAL	6.60
7L	H	3907	SONY ENTERTAINMENT			PAL	6.60
13L	H	4087	CNN INTERNATIONAL			PAL	6.80
14U	V	4113	MULTICHOICE	20600	3/4	PAL	
13U	H	4114	CARTOON/TNT			PAL	6.80
15U	H	4182	MTV INDIA			PAL	6.80

Source: PanamSat

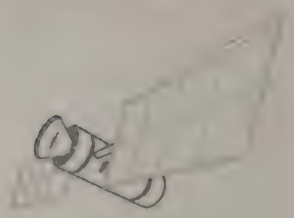




PAS-7

LOCATED AT 68.5 DEGREES EAST LONGITUDE

Launch Date	16/9/98	Country of Origin	USA
Launch Vehicle	Ariane V110	Satellite Type	FS 1300
Mass in Orbit	1800Kg	Stabilisation	3 Axis
Design Lifetime	15 Years	US Space Command #	"TBA"



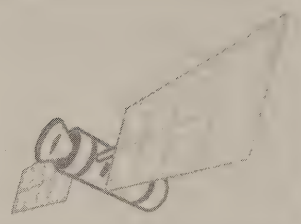
TRANSPONDERS

C Band	14
Power	50W
Bandwidth	14 x 36MHz
Coverage	Asia/Australia
	Europe/Africa
Polarisation	Linear
K Band	30
Power	100W
Bandwidth	30 x 36MHz
Coverage	China/India
	Middle East
	Southern Africa
Polarisation	Linear

INTELSAT 704

LOCATED AT 66.0 DEGREES EAST LONGITUDE

Launch Date	10/01/95	Country of Origin	International
Launch Vehicle	Atlas Centaur IIAS	Satellite Type	FS 1300
Mass in Orbit	1800Kg	Stabilisation	3 Axis
Design Lifetime	10-15 Years	US Space Command #	23461



TRANSPONDERS

C Band	26
Power	10/16/20/30W
Bandwidth	8 x 36MHz
	2 x 41MHz
	16 x 72MHz
Coverage	IOR
Polarisation	Circular
K Band	10
Power	35/50W
Bandwidth	6 x 72MHz
	4 x 112MHz
Coverage	IOR
Polarisation	Linear

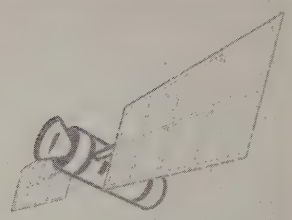
XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO
22L	R	3805	SKY NEWS	22520	3/4	PAL	
25	R	4055	TV 5 ASIA	27500	3/4	PAL	

Source: Intelsat www

INTELSAT 804

LOCATED AT 64.0 DEGREES EAST LONGITUDE

Launch Date	22/12/97	Country of Origin	International
Launch Vehicle	Ariane V104	Satellite Type	GE 7000
Mass in Orbit	1600Kg	Stabilisation	3 Axis
Design Lifetime	13 Years	US Space Command #	25110



TRANSPONDERS

C Band	38
Power	7-22W (Zone)
27-38W (Hemi/Global)	
Bandwidth	8 x 36MHz
	16 x 72MHz
Coverage	IOR
Polarisation	Circular
K Band	10
Power	35/50W
Bandwidth	6 x 72MHz
	4 x 112MHz
Coverage	IOR
Polarisation	Linear

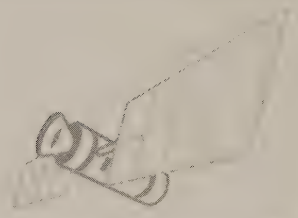
XPDR	POL.	FREQ.	PROGRAMMER	SR	FEC	VIDEO	AUDIO
20L	R	3634	ND TV	5730	3/4	PAL	
86L	L	4084	AFRTS	3680	2/3	PowerVU	

Source: Intelsat www

INTELSAT 602

LOCATED AT 62.0 DEGREES EAST LONGITUDE

Launch Date	27/10/89	Country of Origin	International
Launch Vehicle	Ariane V34	Satellite Type	HS 389
Mass in Orbit	2560Kg	Stabilisation	Spin
Design Lifetime	13 Years	US Space Command #	20315



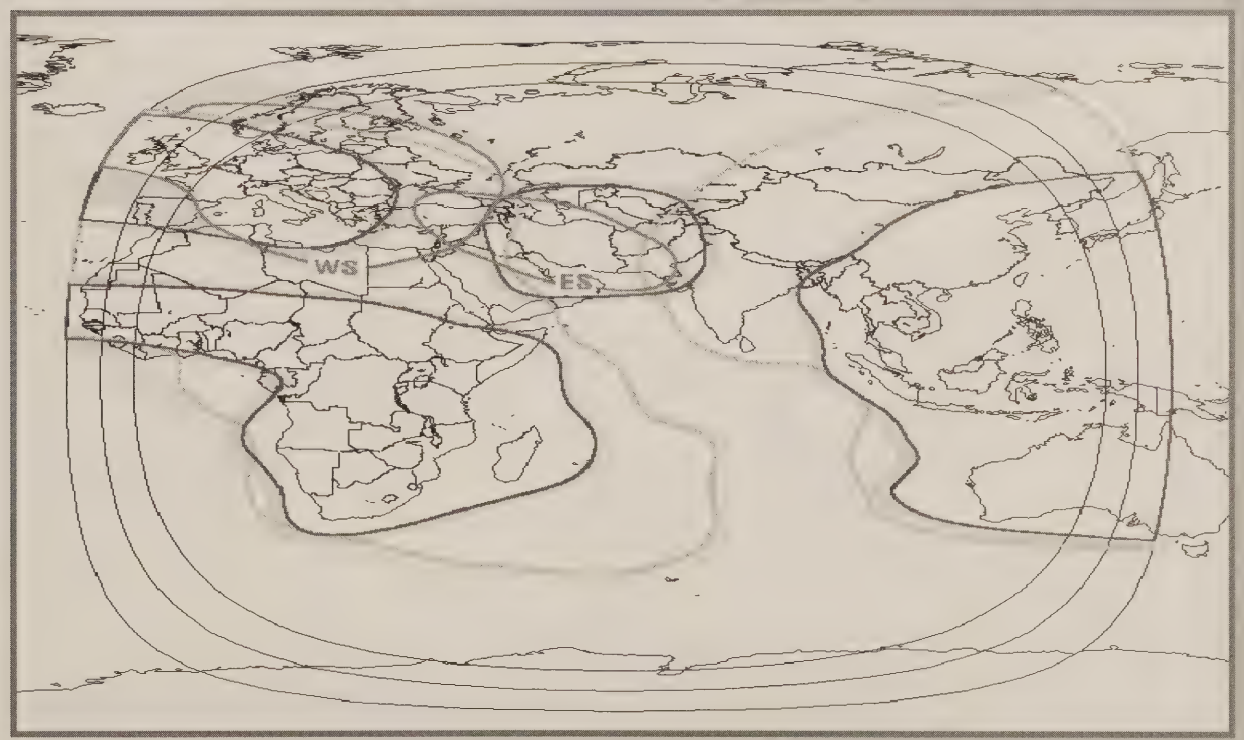
TRANSPONDERS

C Band	38
Backup	12
Power	5.5/10/13.5/16W
Bandwidth	26 x 72MHz
	12 x 36MHz
	2 x 41MHz
Coverage	IOR
Polarisation	Circular
K Band	10
Backup	4
Power	20W
Bandwidth	8 x 72MHz
	2 x 77MHz
	2 x 150MHz
Coverage	IOR
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
	RHCP	4166	ITINERANT	PAL/NTSC	6.60
	RHCP	4188	ITINERANT	PAL/NTSC	6.60

History

Feb 92	24.5 West
April 92	60 East
Oct 97	62 East

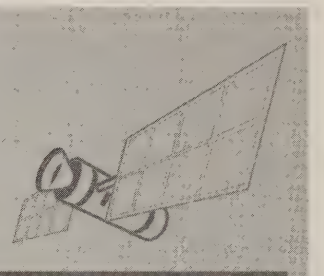


Source: Intelsat www

INTELSAT 604

LOCATED AT 60.0 DEGREES EAST LONGITUDE

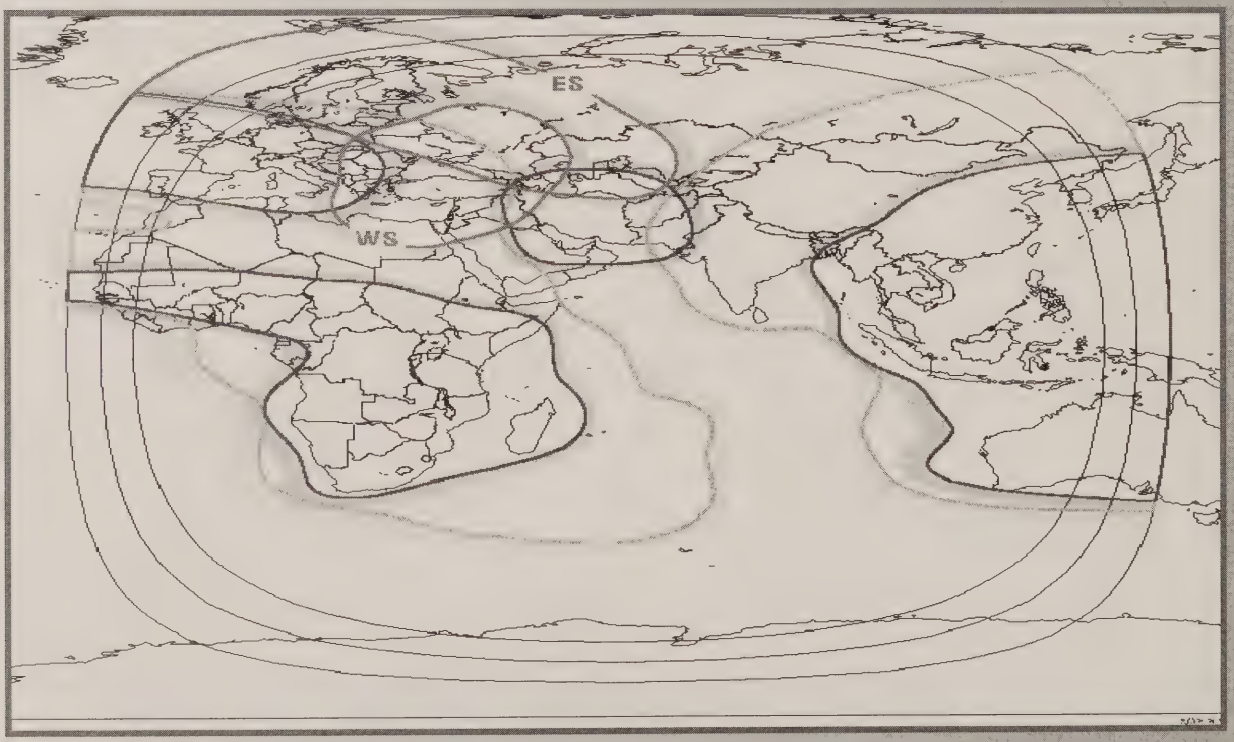
Launch Date	23/06/90	Country of Origin	International
Launch Vehicle	Titan 3	Satellite Type	HS 389
Mass in Orbit	2560Kg	Stabilisation	Spin
Design Lifetime	13 Years	US Space Command # 20667	



TRANSPONDERS

C Band	38
Backup	12
Power	5.5/10/13.5/6W
Bandwidth	26 x 72MHz
	12 x 36MHz
	2 x 150MHz
Coverage	IOR
Polarisation	Circular
K Band	10
Backup	4
Power	20W
Bandwidth	36MHz
Coverage	IOR
Polarisation	Linear

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
	RHCP	4166	ITINERANT	PAL/NTSC	6.60
	RHCP	4188	ITINERANT	PAL/NTSC	6.60

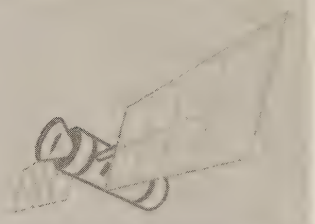


Source: Intelsat www

INTELSAT 703

LOCATED AT 57.0 DEGREES EAST LONGITUDE

Launch Date	06/10/94	Country of Origin	International
Launch Vehicle	Atlas Centaur IIAS	Satellite Type	FS 1300
Mass in Orbit	1800Kg	Stabilisation	3 Axis
Design Lifetime	10-15 Years	US Space Command #	23305



TRANSPONDERS

C Band	24
Power	10/16/20/30W
Bandwidth	8 x 36MHz
	2 x 41MHz
	16x 72MHz
Coverage	IOR
Polarisation	Circular
K Band	10
Power	35/50W
Bandwidth	6 x 72MHz
	4 x 112MHz
Coverage	IOR
Polarisation	Linear

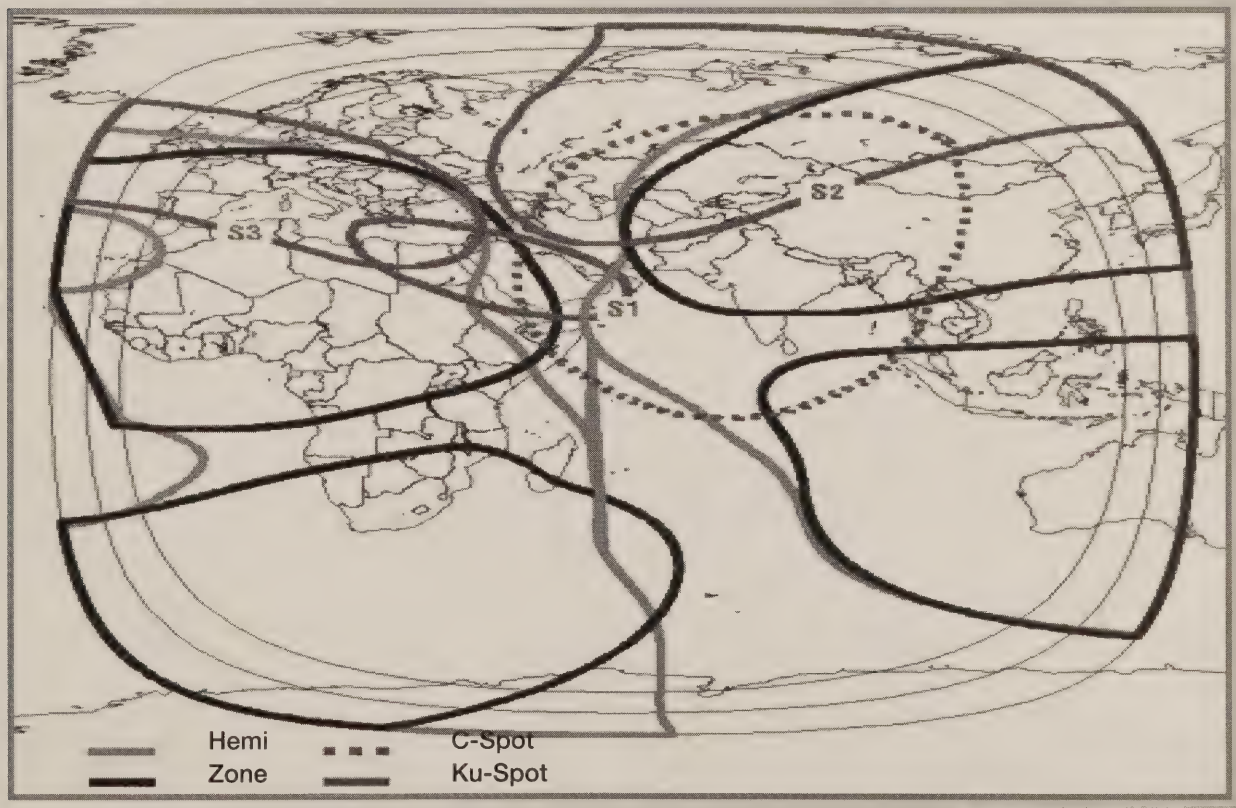
XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
21	RHCP	3750	SUN TV	PAL	6.60
22	RHCP	3808	HEART TV	PAL	6.60
			UDAYA TV		
			UDAYA MUSIC		
			SUN MUSIC		
23	RHCP	3900	SAT INFO SERV	PAL	6.60
			SR18200 FEC 2/3		
24	LHCP	3980	ASIANET/ATVI	PAL	6.60
35	RHCP	4050	WORLDNET	PAL	6.60

History

Initial position 177° East

June 1996 moved to 57° East

Ownership of this satellite transferred to New Skies Satellites, N.V. October 1998.

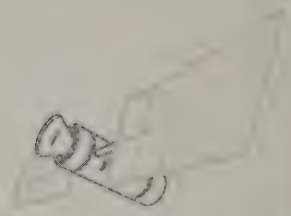


Source: Intelsat www

GORIZONT 32

LOCATED AT 53.0 DEGREES EAST LONGITUDE

Launch Date	25/05/96	Country of Origin	CIS
Launch Vehicle	Proton # 242	Satellite Type	NPO Gorizont
Mass in Orbit	2120Kg	Stabilisation	3 Axis
Design Lifetime	3-5 Years	US Space Command #	23880

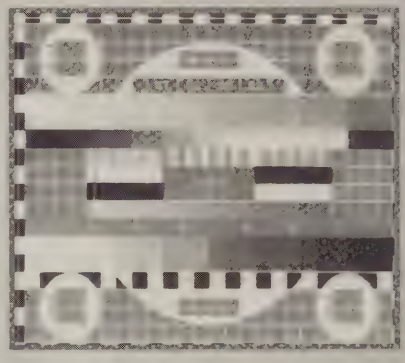


TRANSPONDERS

C Band	6
Power	1 x 40W
	5x 15W
Bandwidth	1 x 40MHz
	5 x 36MHz
Coverage	IOR
Polarisation	RHCP
K Band	1
Power	20W
Bandwidth	36MHz
Coverage	IOR/CIS
Polarisation	RHCP

XPDR	POL.	FREQ.	PROGRAMMER	VIDEO	AUDIO
6	RHCP	3675	ORT-1	SECAM	7.02/7.50*

* Radio Service.



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